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Methodology for Selecting Team Training Techniques

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14. ABSTRACT *(Maximum 200 words)*: This report presents an expert system methodology for selecting techniques to use in team training programs. To arrive at that system, the literature on team training requirements was extensively analyzed. In addition a survey was conducted of sixty subject matter experts (SMEs) in eleven occupations including fire fighting and the military. The SMEs were asked to describe team aspects of their work by responding to survey items under seven dimensions such as task conditions and structure, decision making, knowledge requirements, and teamwork. Intercorrelations of responses across dimensions were calculated to determine clusters of task characteristics. Results of the literature and team task analyses were used to build an expert system. That system takes responses to a 26-item survey and returns a list of training techniques for the subject task. The system has been programmed for use on the Internet.

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METHODOLOGY FOR SELECTING TEAM TRAINING TECHNIQUES

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WELCOME

This site is about how to train people, especially teams. Part of it covers figuring out what to train. Part of it covers how to actually do training.

In the U.S. alone, about $20 billion is spent each year on training. Some of this is a worthwhile investment: Researchers have found up to a 30-to-1 difference in performance between high-training and low-training groups in some fields. On the other hand, some of it is pretty badly spent. With both increasingly complex tasks and increasingly fast change, the need for good training is clear, and it's reasonable to expect the importance of training to grow. The question we address is, how do you design good training?

GETTING ORIENTED

This set of pages provides an overview of training. If you're already familiar with the territory, you may wish to skip ahead.

We'll begin with the four main issues in designing training:

1. What task needs to be done, and how well? This is often easy to say in a general, vague way, and difficult to specify in detail. We talk about this in <Training Basics>.

2. What is currently getting done? Again, saying this approximately is a lot easier than saying it precisely. This is covered in <Training Basics> and in more detail in <How To Figure Out What Your Team Is Really Doing>.

3. What changes could make it better? Once again, easy to do vaguely and hard to do with accuracy and detail. Addressed in <How To Use the Training Guide> and in <The Training Guide> itself.

4. What is the best way to train to get those changes? The big question. Which combination of maybe fifty possible training approaches best fit the budget, the training goals, the resources, and the time-frame? See <The Training Guide>.

HOW TO DO IT WRONG

Why not train it as it has been trained in the past? After all, people and teams have achieved great performances in all sorts of fields using whatever training methods have been traditional in those fields. In fact, training the next generation as you were trained may be a perfectly good idea. But then again, it might not be. Previous results may have been achieved inefficiently and despite poorly designed or poorly executed training.

First, poorly designed training wastes time. It's a rare domain where finding the shortest training route to the target performance isn't highly desirable. There are all sorts of ways poor training can waste time. For example, for years the Navy taught basic principles of electronics to their trainees before introducing them to their electronic equipment troubleshooting tasks. It wasn't until someone actually observed good troubleshooters at work that it was discovered that the bulk of the basic principle material was never used. The best electronic troubleshooters had no more knowledge of basic principles than the newest training graduate.

Perhaps even worse, it wastes motivation. Level of motivation is the best single predictor of performance and improvement. Suppose you have the good fortune to have a crop of trainees who are enthusiastic and highly motivated. They'll pay attention to their instruction, and they'll work hard at practicing. But if people are trained in the wrong thing, or trained in the wrong way, they won't get better. And nothing drains enthusiasm more effectively than hard work with no reward.

The training investment made by both the trainers and the trainees should pay off in measurably improved performance. The way you do it now *may* be the best way to do it. If there's a better way, though, it's worth finding out.

UNDERSTANDING WHAT TO TRAIN

Good training depends on a lot of factors. Motivation has already been mentioned, and it's probably impossible to exaggerate it's importance. Unmotivated trainees don't learn anywhere nearly as efficiently as motivated ones. Shared goals, trainee confidence in real rewards for improved performance, and for teams, a real sense of membership and commitment, all contribute to setting the stage for training. Breakdowns in any of these can sabotage a training program.

Four other factors are critical:

First, explanation isn't the same as performance. Being able to explain something is one thing, being able to do it is another. Otherwise, considering the number of words that have been written, every golfer in the world would be shooting 63's. Because it's often easier to test and measure verbal descriptions than actual performance, though, the ability to explain a task is too frequently mistaken for success in training.

There are some work areas—law, for example—where the ability to argue and to construct convincing explanations is task performance. But even for this kind of task, measuring how well the task is explained (for instance, the ability to recite the rules of argument and rhetoric) is still different from being able to actually do the task, to come up with strong explanations and to persuade people with them.

This isn't to say that explanation isn't a crucial element of many kinds of training. Telling people what to do is most often the most effective approach. However, mistaking trainees' ability to recite back the "right way to do it" with their ability to actually do it is not satisfactory.

The second issue is that it can be hard to figure out what really works. For some tasks, the relationship between cause and effect is murky. Sometimes, this is simply due to the imperfection of current knowledge. But in domains where effects can arise from many causes and causes can result in multiple effects, it can be difficult to say what actions will have what result(s). If work is done in a dynamic

environment - an environment that changes over time - there may not be any single, simple reason why a task is performed well or badly. There may be a constellation of factors, and if the task has multiple steps, these can be quite difficult to tease apart because it may be possible in subsequent steps to make up for lower performance in previous steps. In this kind of situation, many widely differing explanations of performance can be all be to a greater or lesser degree true. Even outstanding performance can be neutralized by unexpected changes in the environment.

In addition, there may be more than one route to the desired task outcome. If Method A doesn't work, then an alert individual or team may try Method B or Method C. This is of course good, but it also means that isolating the reasons for success or failure can be very difficult and error-prone.

Further, all sorts of work areas that involve intensive human interactions—teaching, sales, law—have a significant element of chance, of histories and impulses and unpredictable encounters that can have a big effect on outcome but are completely beyond the control of the performer.

Finally, since no observer comes to a task completely free of prior beliefs and expectations, different observers will see, remember, and interpret the same evidence differently.

If you as a training designer can't tell what causes good performance, it will be hard to design a training plan. If you believe you know what causes good performance and, for the reasons just stated, you're mistaken, it will probably be harder.

The third major factor is the transfer from training to real-world performance, and this isn't as straightforward as it might seem. "Transfer" measures the degree to which training actually changes performance, and it's surprisingly complex. People are highly attuned to situational and historical variables, many of which can be very hard to duplicate in training. Similarities between training and actual performance may appear persuasive, but difficult-to-see underlying dissimilarities can block or dilute the expected transfer. In addition, "compartmentalization" of training (an *a priori* attitude on the part of

trainees that training and the real world are simply not related) can isolate expected training effects.

The final factor is that people are so good at learning, they can learn a lot in training that you never intended for them to learn. People will learn all sorts of things about the trainer, the organizational context in which the training takes place, the actual goals of the training (when these are different from the stated goals), how much is actually expected of them, and a host of other things that may have little to do with the ostensible goals of the training.

Assuming all of these factors can be addressed to a greater or lesser degree, the next step is to look at the issues of training design.

TRAINING DESIGN

Because people are great at learning, there are almost always many ways to achieve training goals. For the same reason, there are almost always many reasons why goals are achieved. (It's common enough that training goals are achieved despite, rather than because of, a training program.) If you mistake the reason(s) a training approach worked for a particular task, which may be easy to do, then you're more likely to combine an inappropriate training design with high expectations on the next task.

The "Hawthorne effect" further complicates training design, because it makes it harder to tell whether or why a change in training approach works. In the 1950's, it was noticed that whenever a new educational reform was introduced, a test classroom demonstrating the new approach would show a significant, even striking improvement in learning. The approach would be widely adopted, but the results would be disappointing. Following the disappointment, a new approach would be developed, pretty much the opposite of the previous one. A test classroom would again show a big improvement in learning. So now, the new approach would be widely adopted. But it would turn out that it, too, didn't really improve things. Why did the test classrooms do so well, while the wide adoption didn't? The Hawthorne effect: The improvement had very little to do with the differences in teaching approach, but everything to do with the enthusiasm and special attention lavished on the test classrooms.

Training design may also have to address not only how to do task but how to (continuously) learn how to do the task better. If the job being trained is something that is constantly changing or evolving, then training has to address dynamic adaptation: Not just how you do the work, but how you change how you do it to adapt as the thing you're doing changes. In any field where there is a significant technology element, this is likely to be an issue. And depending on the specifics of the job being trained, this can be an especially sensitive area for interaction of training with long-term motivation.

Once you've designed a training program, you need to test it. In some fields—police and firefighting, medicine, military affairs—performance data can be hard to get. In some cases, even if it exists, it is considered sensitive enough that it may not be available for

inspection. Getting a good picture of the effect to training on performance can require integration of partial evidence from a large number of sources, each of which may vary in the degree to which they are similar to the actual conditions for which you want to train. This is easily connected to a a temptation, often entirely unconscious, to "test what you've trained," just because testing for the real point of the training, namely, real-world performance, is so hard.

DOING IT BETTER

We've just described some reasons why training is hard. But there's a bright side, too. Even though to develop a good training program, a lot of decisions with uncertain answers must be made, the uncertainty of the answers can be greatly reduced with improved methods for understanding tasks and selecting training methods:

- Task analysis techniques have multiplied and been refined into powerful tools for analysis of individual and team behavior.
- Cognitive task analyses can lead to better understanding of the mental roots of performance, performance breakdown and stress points, and better design of appropriate training materials.
- Metacognitive analyses—improved understanding of how we control our own thinking, how and for how long we focus our attention, when we know we don't know something, and so on—and explicit training of domain-specific metacognitive techniques have been shown to lead to significant improvements in task performance.
- Organizational, sociological, and training researchers have developed insights into the nature and operation of teams. This has laid a foundation for group cognitive task analyses to provide tools and techniques for better understanding of, and therefore training of, group behaviors and performance.

There's a lot of hard work involved in developing a training program and seeing it through implementation and testing. But insights about learning and human capabilities (and frailties) that have emerged from experimental and evolutionary psychology, cognitive science, artificial intelligence, and the decision sciences have all contributed to better tools for understanding human performance. At the same time, improvements in technology have made some kinds of training approaches, especially computer-based simulation training, both possible and affordable.

So - how to do it? As we proceed, we'll propose a systematic method for determining, for a particular task or competence, what is the most effective way to train.

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BASICS OF TRAINING & TRAINING DESIGN

In this set of pages we go over the basics. We start by talking about learning - its different forms, as seen by the learner. Then we define just what we mean by "training" and "training design." We describe the eight characteristics of teams that are important for training. This section concludes with a review of the nine steps in training design.

<Learning>
<How learning works>
<Expertise>
<What training is>
<Training design>
<Teams>
<The ten-step approach>

LEARNING

Learning is goal-driven persistent adaptation to a perceived environment.

OK, what does *that* mean? First, learning is powered by the impetus to achieve some goal. The impetus doesn't have to be conscious - infants don't make well-considered decisions about whether to learn to talk. But even the earliest learning, the most strongly biologically programmed infant development, is altered by the strength of the goals. Babies who have colorful mobiles to reach for learn coordination more quickly than those who don't.

Second, it only counts as learning if it lasts. If you forget the lesson the moment you walk out the door, it doesn't count as learning. This doesn't mean all learning has to be conscious, of course - simply that it has to last long enough to be of service to the goal(s).

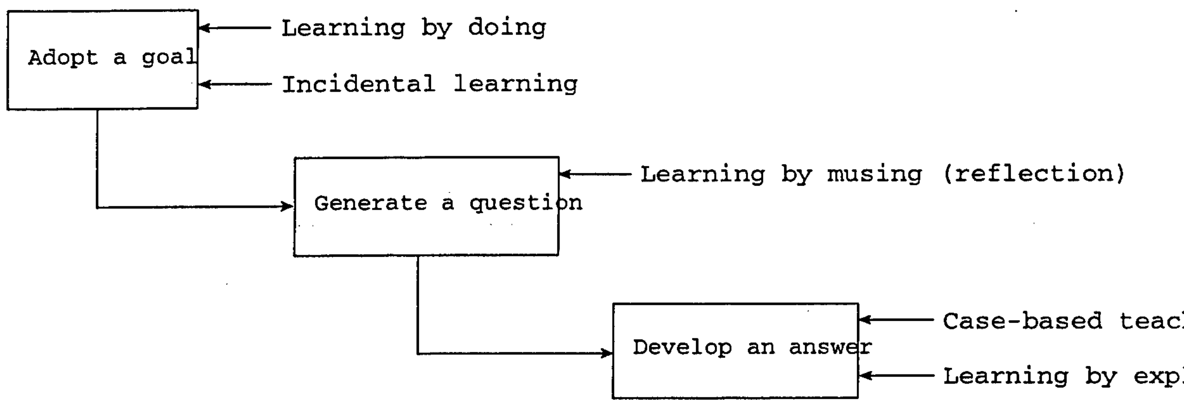
Third, learning usually means a change that makes you better at achieving your goal. This is a little tricky, because some goals are members of "goal classes." You might not learn how to solve the current problem, but something that makes you better at solving that *kind* of problem. It's also tricky because achieving some goals requires going backwards before you can go forward. As a simple example, sometimes learning more options can make it harder to decide what to do.

Finally, learning never takes place in a vacuum - it *always* happens in some environment. And which elements of that environment are perceived in what ways has a big effect on what is learned. Since a big part of training design is the design of environments, this is important.

Learning is an active, constructive process, in which the learner is the principal actor. The learner actively builds, tests, repairs, and refines his or her understanding, skills, and abilities. Learning is action.

HOW LEARNING WORKS

Roger Schank and Chip Cleary describe learning as a three-stage process, the "learning waterfall."



They observe that people spontaneously learn about things that are interesting to them, that is, that pertain to their goals. We move from specific experiences to more general understanding, what Schank and Cleary call "rich generalization," so-called because since real experience always includes exceptions and borderline cases, our spontaneous generalizations are fluid and flexible, in contrast to dry, memorized textbook rules.

We pursue our goals, learning as we do things and as we encounter things along the way. We consider what we want to do next (generate a question), and we learn in the process of figuring out what to ask, who to ask, how to ask, what perspectives are possible, what can be articulated, how to move forward, what isn't known,and so on. To develop an answer, we think about similar situations, recall, compare, and evaluate stories and things we've read or been told; we try things out, perform experiments, and we practice what we've learned.

Schank and Cleary claim that the more teaching and training cleave to the waterfall, the less work and the more benefit there will be.

EXPERTISE

People have always admired experts, but as an area of empirical research, it has a short history. DeGroot's experiments on chess players (1946) were the first systematic studies of experts.

The current research consensus on expertise is that it is a function of both knowledge and, probably more importantly, knowledge organization. For example, physics graduates will search through their knowledge to find the right problem solving techniques, but experienced practicing physicists will simply "see" the appropriate approach as part of understanding the problem. The knowledge is organized in such a way that they can apply it quickly and fluidly.

It typically takes no less than ten years to develop expertise - and a decade of practice appears to be necessary, but not sufficient. Just doing the same thing for ten years does not an expert make. How you do it counts.

The key to development of expertise seems to be "deliberate practice." Deliberate practice is practice that meets four extra criteria:

- The task is appropriate. That is, the thing being practiced is a useful thing to practice in order to increase the learner's capability. (This should go without saying, but unfortunately, it does not always hold true.)
- Appropriate level of difficulty. Hard enough to be challenging, not so hard as to engender bad habits or discourage further practice.
- Informative feedback. The learner can tell or be told the effects of his or her actions.
- Opportunity for repetition and correction of errors. Things that need to be corrected or improved can be worked on directly.

These may all seem obvious, but for each one, counterexamples are easy to find. At any given time in a crowded elementary school classroom, the task is unlikely to be appropriate for a large number of students. A Marine commander doesn't get much chance for repetition and correction of errors.

Training to develop expertise is a long-term project.

WHAT TRAINING IS

Training is any activity that produces a persistent change in behavior or competence, in a person or group, with respect to a task or family of tasks.

The training goal should always be:
Do it better in the world.

Why is it necessary to say this? Because there are plenty of places where it is completely ignored. How many schools reward students for little other than being good at going to school?

For some kinds of work, an additional training goal may be to improve the trainees' self-directed ability to to learn on the job, so that the' competence continues to increase long after formal training is completed.

TRAINING DESIGN

Training design is the selection or creation of environment(s), events, and sequences for an individual or group so that a desired (actual task) performance capability arises and persists.

In other words, what do you want them to see, hear, feel, and think, in order to be able to do what they're supposed to do?

The environment and its content are conditioned by social, ethical, political, and aesthetic values. You may have to consider all of these in training design.

"Training transfer" is what shows up in the real world as a result of training. The basic rule of transfer from training to practice: The more similar the environment(s), events, and sequences of training are to those of the real task, the more effective the transfer.

THE NINE-STEP APPROACH TO TRAINING DESIGN

Gagné, Briggs, and Wager (1992) propose a nine-step instructional design sequence.

1. Define the instructional goals.
Instructional goals address the gaps between the desirable state of affairs and the current or observed state of affairs. In other words, what can't they do that you want them to be able to do? New ideas or new technology can also call for creation of instructional goals.

2. Conduct instructional analysis
"Instructional analysis" is the process of describing the task(s) to be trained. Representative kinds of instructional analyses are task analysis, cognitive task analysis, and learning analysis. The various task and cognitive task analyses are covered later <INSERT LINKS HERE>. Learning analysis discriminates between terminal and enabling objectives, that is, the final result and what they need to know or be able to do in order to achieve the final result. It also addresses the sequence of enabling objectives, that is, what to learn first. (Why educators need to say "sequencing of enabling objectives" instead of "what to learn first" is beyond me.)

3. Identify entry behaviors and learner characteristics
Determine which required enabling skills the learners already have, and note any other characteristics of the learners germane to developing instruction. That is, figure out who you are training.

4. Identify performance objectives
Translate needs and goals into specific, detailed objectives. Detail is necessary both to development of training materials and to creation of measurement tools (colloquially called "tests") to assess student progress and determine the degree of success in achieving the objective(s). A good learning objective has:

- A statement of the behavior (action) or understanding the trainee must show, that is, the desired result of training. This can be either positive or negative. For situation A, the goal may be to perform X, or it may be to avoid or refrain from performing X.
- Specification of the conditions under which the behavior must take place.

- A statement of the standards for satisfactory performance.

Some kinds of training goals are easier to characterize via the behavior/ conditions/standards approach than others. For example, "teamwork" is harder to specify and measure than "operating a radio." Getting the statement of a training objective right is critical. Conditions and standards are frequently inadequately specified in training system development.

Gagné et al identify five classes of outcome.

1 Intellectual skills. Learning how to do something of an intellectual sort. The ability to interact with the environment (broadly construed) in terms of symbols and concepts, and/or the learning of procedural knowledge.
2 Cognitive strategies. Skills for governing thinking. This includes both operational and predictive knowledge. For example, having appropriate expectations, and knowing how much certainty to invest in them, is a critical skill of competent commanders.
3 Verbal information. Declarative knowledge, and the ability to integrate it with other knowledge and to recall it appropriately.
4 Motor skills. Physical skills, and (to the extent not covered by other categories) knowledge of how and when to apply them.
5 Attitudes. A persisting state within the affective domain that consistently influences or modifies an individual's choice of actions. Attitudes are immensely important in some work - police, the military, athletics.

Within intellectual skills, there are five subcategories: problem-solving, rules, defined concepts, concrete concepts, and discrimination. In reverse order:

- Discrimination involves distinguishing features of objects or situations as similar or different, e.g., a red Ford Taurus is the same as a blue Ford Taurus except for the color.
- Concrete concepts involve identifying a class of object characteristics, objects, or events, e.g., "that's a Ford Taurus".
- Definitional concepts involve classification of an object or event in accordance with a definition, e.g., a Ford Taurus is a domestic car.
- Rules require knowing rule content, conditions, and in most cases exceptions, along with the competence to apply the rule

correctly. For example:

Water expands when it freezes =>
Don't freeze water in an inelastic container =>
Don't fill your Taurus' cooling system with water if the temperature is likely to go below 0° C.

- Problem-solving involves generating a solution to a novel problem, e.g., predicting the sale of right-hand drive Tauruses in Japan.

5. Develop criterion-referenced test items
Criterion-referenced test items determine whether the students have acquired the desired skill, rather than merely showing they remember the instruction. These are necessary for training evaluation. They can also be used to place students within a training program, by determining which of the enabling and terminal objectives they have already mastered.

6. Develop instructional strategy plan
Instructional strategy is a plan for assisting learners with their study efforts for each performance objective. It is a mapping of instructional activities to accomplishment of objectives, as well as diagnosis and prescription of the most apt instructional approach for the objective.

7. Develop instructional materials
The selection and development of instructional materials.

8. Conduct formative evaluation
"Formative" means that the course is being revised and tuned through this evaluation. A three-step approach is advocated by Dick and Carey (1990). First, try the materials one-on-one. Then, try the materials on a small group of students. Then, perform a field trial in which the instruction is revised based on the whole class. (This is of course subject to the kind of objectives and material involved.)

9. Conduct summative evaluation
Evaluate the course or training program after it has been implemented and put in place.

There is a lot more than these nine steps to instructional design. In actually developing a training course, resources, the environment, other constraints, teacher preparation, installation, and diffusion all

have to be considered.

TEAMS

Teamwork is different from "taskwork." Taskwork is what individuals do by themselves. Sometimes "teams" are just groups of people who do their individual tasks side-by-side. An assembly line is an example of this kind of taskwork. Teamwork happens when team members need to interact to achieve common goals, and their interaction includes adapting to changing circumstances.

There are eight elements of teamwork:

1. Shared, usually conscious goal(s)
2. Mutual monitoring
3. Communication
4. Feedback
5. Reciprocal backup
6. Membership awareness
7. Interdependence
8. Shared skills

Sharing goals, usually consciously, is pretty much the basic thing that distinguishes a team from a group of people who just like to hang out together. Seriously, a major mark of team coherence is the degree to which team members share goals, and even moreso, the degree to which they are willing to put aside their personal desires in favor of team success.

More on...
<Mutual monitoring>
<Feedback>
<Communication>
<Reciprocal backup>
<Membership awareness>
<Interdependence>
<Shared skills>
<More aspects of team tasks>

TEAMWORK: MONITORING

Monitoring includes observing teammates behavior, checking that procedures or actions are correct and timely, that teammates are not in need of assistance, that appropriate progress is being made toward the goal of the team.

Issues affecting monitoring include: Shared mental models of the task, including mental models of other team members' expected behavior, and mental models of other team members' beliefs and attitudes; mutual trust; ease of monitoring (physical proximity, clarity of cues as to performance status, obviousness of engagement); and, the pace of change during task performance.

If team members are not close together during task performance, then shared mental models of task performance are important to maintain actual and perceived synchronization. Even if an individual is being trained for a specialty, he or she should receive training in other relevant task activities.

If diverse backgrounds are common, training in both expected standards of professionalism and specific culture-sensitive modes of communication should both be considered.

If the pace of change during task performance is very rapid, or has the potential to be rapid, then training in modeling task performance, including critical incident training, should be combined with active practice at anticipation of possible situation development and teammate performance trajectories.

TEAMWORK: FEEDBACK

Feedback is a follow-up activity to monitoring. Giving and receiving feedback is a critical technique for taking advantage of strengths and compensating for weaknesses in a team, and for group improvement and optimization.

Issues influencing feedback include whether it is direct or mediated (for example, through a mutual superior); the roles of status, tenure, and rank in affecting feedback flow; whether feedback is explicitly or implicitly communicated (implicit communication might be through attitudes, degrees of cooperation, physical postures, etc.); whether there are "post-event" reviews; and whether there is any potential for reprisal for unwanted feedback.

TEAMWORK: COMMUNICATION

Communication is critical not only in feedback, but is the way many tasks are coordinated and executed. Communication issues include whether there is an open channel, a constrained ("only when asked") channel, a clogged channel, or a closed channel; whether communication is task oriented only or includes a wider range of topics; whether communication can occur at any time, or only at designated times; and whether there are special methods to "close the loop" (confirm communication correctness).

If a particular kind of channel is organizationally sanctioned, trainees should know it and how to behave appropriately. If the nature of the channel is dependent on individual leaders' or teams' styles, training should prepare trainees to adapt to whatever style they encounter, with professionalism "from below."

Some tasks have specific task-oriented communications, like the copilot's role in providing information to the pilot when landing a plane. Such communications are often somewhat formalized; appropriate forms should be trained and rehearsed. In some tasks, the task pressure is great enough to perturb normal communication; if this is known to happen sometimes, immersion in (simulated) task conditions is appropriate.

If communication is to happen at designated times, or if time for communication is limited, then thorough familiarity with task-specific jargon is necessary. Classroom introduction should be followed by rehearsal, practice, and feedback.

If closing the loop is part of the job, "false model training" might be used to augment normal training, in order to prevent trainee guessing and covering of misunderstandings.

TEAMWORK: RECIPROCAL BACKUP

Backing each other up is the hallmark of teamwork. Feeling welcome to jump in if the need is perceived, and accepting others' jumping in without fearing being perceived as weak, indicate strong reciprocal backup.

Some reciprocal backup issues include the degree of task specialization versus the pool of common skills; whether there is physical task trading and/or sharing; whether there is emotional or attitudinal task trading or sharing (as in, for example, medicine); whether there is intellectual task trading and/or sharing; the role of anticipation in backing up appropriately; and, the role of "anticipatory compensation," that is, of doing something so backup is less likely to be needed.

TEAMWORK: MEMBERSHIP AWARENESS

In general, team members must be aware of themselves as part of a team, see themselves as team members, and be willing to put team success above individual goals. Some issues that influence this include explicit markers of team membership (uniforms, physical separation, special tokens, special treatment); a sense of being part of team; pride or other intangible elements of team membership (like a sense of being recognized as part of team); explicit expectations for team obligations; explicit expectations for team benefits; and, the notion that the team is more important than the individual, that the team member will sacrifice individual goals to the team goal.

Putting the team above individual desires is probably the single most important aspect of teaming. It is hard to achieve—in athletics, coaches are always emphasizing team (Gruff voice: "Men, there's no 'I' in team.") External focus during training on the importance of shared goals can help; minimizing any "star system" can also help.

TEAMWORK: INTERDEPENDENCE

Teamwork is defined as involving interaction. Part of that is the attitude of interdependence: willingness to accept interdependence, confidence in teammates, assumption of responsibility, perception of reliability.

Some interdependence issues are the degree to which each task is structurally intertwined with the others; the degree to which attitudinal and motivational factors require perceived support; the degree to which the nature of the task encourages/requires interdependence; and, the degree to which the task culture supports interdependence (for example, firefighters living together when on duty).

If tasks are structurally intertwined, the on the job interdependence will be functionally required. Training in standards of professionalism can help this go smoothly.

If the nature of the task requires interdependence (firefighting and police work share the characteristic that one's life may depend on the alertness and competence of coworkers), the perceived rigor of training and ongoing OJT support development of appropriate attitudes.

If the task culture does not explicitly support development and maintenance of attitudinal interdependence, then training should explicitly emphasize interdependence, e.g., by simulating task performance with dependent support withdrawn. In addition, appropriate expectations should be trained.

TEAMWORK: SHARED SKILLS

It is often the case that different circumstances call for different styles of teamwork. In one situation, a clear and commanding leader may be needed; in another, a more organic group adaption is appropriate; and in a third a democratic approach might be best. But, different tasks call for different degrees of stylistic flexibility. There are two issues: Degree of flexibility required of team with respect to style, and degree of autonomy of subteams once subtask assignments are made.

If a great degree of style flexibility is needed, then specific role-playing exercises are potentially useful. The culture of the organization (including especially the perception that leaders are selected fairly according to appropriate standards) is also important.

If subteam autonomy is important, role playing within subteams, and clear instruction on how authority is managed are both suggested.

TEAMWORK: MEMBERSHIP STABILITY

Teams change over time. This change can be the result of turnover in members, or in stable teams, mutual adaption, trust, and team efficiency.

The issues: How membership-stable are teams? And, how important is membership stability, i.e., how much tacit team adaption to incident circumstances is shaped by team members' knowledge of one another's strengths, weaknesses, and preferences?

If teams are stable, and the rate of introduction of new members is gradual, then the overall degree of attitudinal training may need to be less, and more training can safely be on the job (OJT).

If stability is important, then training in standards of professionalism is useful.

MORE ASPECTS OF TEAM TASKS

To design training, of course you need to know your subject. It is also useful, though, to understand your subject in a more abstract way. The advantage of this is in allowing identification of tasks with similar characteristics. If you can do that, then the pool of training practices from which you can draw is just that much richer.

What do we mean, though, by an abstract understanding of a subject? We've just listed eight abstract characteristics of teamwork, on each of which any particular job or task could be ranked. Here, in more compact form, are ten more. Above, we looked at teams directly. Now, we consider some of the elements of the tasks for which teams are formed Does your team...

1. Perform diverse tasks, which vary in both criticality and urgency. "Criticality" is how important a thing is. "Urgency" is how important timing is to a particular activity. People sometimes confuse urgency with criticality, thinking that anything that has to be done Real Soon must be important for that reason alone.

2. Coordinate multiple interacting tasks to meet overall objectives.

3. Adapt to unanticipated demands and opportunities for action generated by dynamic external entities. Fire, police, military, and athletic teams all do this. Company teams do it too, over longer time-frames.

4. Satisfy real-time constraints. That is, work with real deadlines, as in medicine.

5. Operate within resource constraints. Who doesn't? But for some teams and tasks, resources are a bigger problem than for others.

6. Operate within human motivational, perceptual, reasoning, and executive constraints. This is a bigger issue in the military than in most other areas, those some brands of athletics also encounter it.

7. Operate within intrinsically uncertain information and knowledge

environments. Again, no task enjoys perfection, but it's more of an issue for some kinds of work than for others.

8. Dynamically revise and modify goals.

9. Deal with "identifiability" issues, that is, uncertain association of effect with cause, in an environment where events can have multiple causes and causes can trigger multiple events, and where causes and events can be quite distant from one another

10. Perform under stress.

It probably seems complicated to try to keep track of all of these factors. It does to us. In a later section, we'll provide an automated way to assess your team and its work.

TEAMWORK RESEARCH FINDINGS

Our research goal was to look at the interrelations between tasks and teamwork. Do dangerous tasks have higher levels of mutual monitoring? Do tasks in which errors are potentially very serious have higher levels of reciprocal backup?

In this section we describe our research on teamwork. After a brief recap of the eight elements of teamwork, we discuss both problems in the study of teamwork and the reasons to expect continued progress.

We'll then describe our data gathering and analysis in detail. The section ends with our assessment of the results.

ELEMENTS OF TEAMWORK: MICROREVIEW

We've reported the common distinction between taskwork and teamwork: Taskwork is side-by-side, either in parallel or serially, while teamwork is interacting and mutually adaptive, with perceived common circumstances and shared, valued goal(s).

The eight elements of teamwork are:

Mutual monitoring
Feedback
Communication
Reciprocal backup
Membership awareness
Interdependence
Shared skills
Stability and development

PROBLEMS OF CLASSIFICATION, REASON FOR HOPE

The ideal thing would be to have a taxonomy of task types with associated best-possible training approaches. This, however, is harder than it seems.

There are many taxonomies of human work and performance. The first problem with construction of a taxonomy is deciding on what basis to classify. Do you classify by aspects? If so, which aspects, at what level of abstraction? Or by function? Or by generic task category? Or by subject matter? Or according to a particular epistemology? Or some hybrid combination of any or all of these?

Existing taxonomies have to some extent been overtaken by events. As our understanding of cognition grows, many of the assumptions upon which taxonomies have been constructed in the past have been undermined. Integrative trends in developmental, evolutionary, and cognitive psychology, along with advances in neurology have changed the current picture of how human thinking works:

> "Human reason depends on several brain systems, working in concert across many levels of neuronal organization, rather than on a single brain center. Both 'high-level' and 'low-level' brain centers, from the prefrontal cortices to the hypothalmus and brain stem, cooperate in the making of reason." (Damasio 1994)

Recent results in language understanding (e.g., Damasio et al 1997) show an extraordinary and previously unsuspected degree of distribution of brain activity in understanding even the simplest concepts. Thus, when seen from a neurological perspective, what we've previously thought about which activities are similar to others is called seriously into doubt.

The positive side of this is that as a deeper understanding of cognition emerges, the foundation upon which understanding of human performance can be built becomes more substantive.

SURVEY STRUCTURE

We wished to adequately characterize team task performance is such a way that training recommendations can be made. The following questions attempt to characterize tasks. Before listing the questions, a view of the overall structure of the questions may make the logic easier to follow.

- Task conditions
  - Physical environment
  - Information environment
  - Working environment
  - Resources
- Task structure
  - Event variability, frequency, and gravity
  - Attention, responsibility, motivation, vigilance
- Decision making
  - Steps
    - Assessment
    - Diagnosis
    - Prescription/planning
    - Execution
    - Evaluation
  - Approaches, outcomes, and issues
    - Methods
    - Solutions
    - Uncertainty
    - Self-management
- Knowledge
  - Facts
  - Procedures
- Teamwork
  - Mutual monitoring
  - Feedback
  - Communication
  - Reciprocal backup
  - Membership awareness
  - Interdependence
  - Shared skills
  - Stability and development

- Errors
  - Physical
  - Fatigue
  - Mental
  - Self-management
- Leadership

SURVEY QUESTIONS

The survey questions, with some explanatory text.

SECTION I: CONDITIONS

All jobs are done in some kind of environment. For some kinds of jobs, the environment is highly controlled. A surgical theater is an example. In other kinds of jobs, there is almost no control at all of the environment. Police work is often like this. Other things count as job conditions. Whether you have to do many jobs at once, how much and how reliable your information input is, the physical environment in which you work, and whether you can get the resources you require when you need them are all examples of work conditions about which we will ask questions in this section.

PHYSICAL ENVIRONMENT

In this section, we will be asking you questions about the physical environment in which you work. The physical environment includes levels of noise, temperature, humidity, and light as well as conditions that may affect the environment such as fire, wind, earthquakes, etc. Later in the questionnaire we will be asking about other aspects of your work environment (e.g., social, cultural, the work itself, the sources and flow of information). For now, please consider only the physical environment when you answer the questions in this section.

1. To what extent is the environment in which the task must be performed physically stressful (e.g., loud noise, challenging or threatening physical circumstances)?

2. To what extent is the environment in which the task must be performed emotionally stressful (e.g., possible ambush, sudden catastrophe, extremely serious consequences of errors)?

3. To what extent is the physical environment in which the task to be performed fast-changing?

INFORMATION ENVIRONMENT

The questions in this section ask you about the information you use to do your work. For example, you may receive information on paper in the form of reports, test results, memos, books, newspapers, or journals. Or, you might receive spreadsheets, text, data, or graphics electronically through e-mail, software, computerized databases, or the internet. You may be given information by other people over the phone, through radio transmissions, or in person. In some jobs, information is largely received aurally (music, dance, radio operator). Other jobs (e.g., dance, sports, fire fighting, visual arts, and theatre) also depend on information that is obtained visually.

When answering the questions in this section, think of the type of information you receive as a whole however you put it together from whatever sources you have. In addition, we are interested in your information environment when you are performing your work. We are not concerned with the information you use during training, learning, or rehearsal.

4. To what degree is information receipt (inflow of data, reports, updates, etc.) reliable? (This is a question about how easy it is to obtain information, not about its quality. For example, if you have a highly reliable supply of really lousy information, you would circle "6" or "7".)

5. To what degree are you swamped with information? (We distinguish between the total flow of information and the subset of useful information. Here we are concerned only with total information flow.)

6 To what degree do you have useful, applicable information?

7 To what degree do you need to examine your information to determine which of it is valid, timely, and useful?

8 To the extent that you need to examine your information, what degree of skill is required to do this well?

9 To what degree is information normally adequate to your needs?

(Do you have the right information?)

10 To what degree is information extraction from the environment difficult?

11 How complex is the notation in which information is presented? (Mathematical and musical notations are examples of complex notations.)

CORE AND CONCURRENT TASK STRUCTURE

Some jobs require that a person do more than one task at a time (e.g., police officers must concurrently drive a car, be aware of the surroundings, and talk on the radio). Other jobs, like surgery for example, require complete concentration, and rule out attending to other tasks at the same time. We'll now ask you questions about the number of tasks that must be done concurrently. These are not subtasks that must be attended to alternately, switching from one to the other. Instead, we are concerned with subtasks that must be done at exactly the same time.

In the following questions, when we talk about "core tasks" we mean any activities that contribute to the achievement of your main goal(s). We distinguish these from non-core tasks: Any tasks that are peripheral or unrelated to the accomplishment of the most important goal(s) of the work.

12 Based on your own subjective perception of your work, how many core tasks [those associated with or required for accomplishment of your main goal(s)] need to be done at one time?

13 To the extent that must do many things at once to achieve your goal(s), to what degree do the demands of the various subtasks conflict?

14 To what degree are there other tasks, distinct from the core task(s), that must be performed at the same time as the the core task? A "distinct task" is any that is peripheral or unrelated to the accomplishment of the most important goal(s) of the work.

For example, a firefighter might have to talk with reporters while fighting a fire. By contrast, a surgeon would not have to talk to reporters while performing surgery.

15 To the extent that there are other non-core tasks, to what degree do the demands or goals of these other tasks conflict with the core task?

RESOURCES

Effective job performance requires particular resources be made available to the worker. For example, fire fighters need the appropriate vehicles, manpower, equipment, water, and chemicals to put out fires. Musicians require performance space and instruments to perform. Similarly, dancers need appropriate costumes, shoes, and physical space for their performances. In this section, we are asking about the resources required for your job performance. When answering the following questions, do not consider the resources required to prepare to perform your job, such as rehearsal space, training tools, educational materials, practice time, or financial support that contributes to learning your trade. We ask about only the resources required to do the actual work.

16 To what degree is access to resources varied and somewhat uncertain?

17 To what degree do task elements require unique resources, in contrast with having many alternatives?

SECTION II: STRUCTURE

The questions in Section II, Structure, concern the external factors that influence how your work is organized. In this section we make a distinction between "event oriented" and "continuous" task domains. The structure of some kind of work, firefighting for example, is determined by the nature of external events (in this example, fires or toxic spills). Other kinds of work are better characterized as ongoing, continuous processes. Building construction is an example of a continuous process. Note that a process may go through distinct phases and still be considered continuous. Also note that an event-oriented domain may feel "continuous", or at least highly predictable (regular Sunday performances for a church choir, for instance.) Some kinds of work combine both events and continuous processes. Nursing is an example.

EVENT EXTENT AND VARIABILITY

If the events you encounter in your work are very different from each other, then they can be said to be variable. For example, an event that some police officers face is a domestic dispute, which is very different from stopping a drunk driver or arresting a graffiti artist. In this case, police work is best described as highly variable. The questions in this section of the survey ask about the variability of events in your work.

18 To what degree are task events (episodes) variable?

19 To the extent that there is variability among events, to what degree is the difference one of size and/or complexity?

20 If there is variability between events, to what degree is the difference one of potential seriousness?

EVENT FREQUENCY

In this section, we are interested in the frequency of events. For some jobs, events are relatively infrequent, e.g., major canyon fires

in fire fighting. For other jobs, events occur very frequently, e.g., traffic offenses in law enforcement. In the following, we ask you about the frequency of events in your work.

21 To what degree are there common categories of events?

22 If there are wide variations among events, to what degree are "minor" task episodes frequent? (If there are not wide variations, please mark this question "N/A".)

23 If there are wide variations among events, to what degree are "major" task episodes frequent? (If there are not wide variations, please mark this question "N/A".)

24 If there are not wide variations among events, to what degree are are task episodes in general frequent

EVENT GRAVITY & CONSEQUENCES

The seriousness of errors associated with events varies. The consequences of making a mistake while flying a fighter airplane during a dogfight can be severe, while the consequences of incorrectly filling out a traffic citation form are less so. This section contains questions regarding the consequences of errors in events.

25 How serious are the consequences of errors?

26 To what degree can errors normally be amended or compensated for by future actions?

ALLOCATING ATTENTION AND RESOURCES

When your work is a more or less continuous process, knowing what task to attend to and spend time working on is a big part of many jobs. In some work domains, team members must know how to allocate both their own time as well as available resources. This section of the survey contains questions that address the allocation of worker's attention and resources.

27 To what degree does good job performance require knowing how to effectively allocate your attention to a variety of tasks?

28 To what degree does good job performance require the ability to set effective priorities?

29 To what degree must you anticipate what will be needed and make small predictions in your work?

30 How important is knowing how to allocate your physical or material resources?

31 How often do you typically need to reconsider or reallocate your physical or material resources?

32 What degree of reallocation or redirection of physical or material resources is common?

33 How important is knowing how to allocate your personnel resources?

34 How often do you typically need to reconsider or reallocate your personnel resources?

35 What degree of reallocation or redirection of personnel resources is common?

RESPONSIBILITY

Knowing what you're responsible for, what the team is responsible for, when subtasks need to be completed, and completing them on time are important components of many jobs. In some cases, determining a deadline for completing a task depends on understanding how that task fits into the big scheme of the work and how it contributes to the overall goal. The questions in this section pertain to workers' responsibilities, with an emphasis on timing and coordination.

36 How important is it for each team member to understand how their work contributes to the overall goal, i.e., how it fits into the

"big picture"?

37 To what degree can you and other team members alter and adjust your work to better fit the current situation and needs?

38 To what degree is estimating how long it will take to complete a task part of the job?

39 How severe are the consequences of not completing a task on time?

40 How important is knowing when to perform tasks?

41 To what degree is your work interwoven with that of your teammates? Said another way, how sensitive is your work to everyone on the team being in sync, completing subtasks on time and in the right order, and generally being connected?

MOTIVATION

Motivation is usually a critical factor in job performance. Maintaining high levels of motivation can be particularly important when the work must be conducted over a long period of time. For example, the extended durations of product development projects, typically many months to many years, may make it difficult for team members to maintain high levels of motivation.

42 How motivated, typically, are team members in your work over the entire duration of the work?

43 To what degree does motivation vary over the full course of job performance?

44 To what degree does the continuous nature of the work make it difficult to maintain a high level of motivation?

45 To what degree do team members in your kind of work typically mutually support or reinforce maintaining high levels of motivation for the team as a whole?

46 To what degree does motivation depend on job rewards (salary, benefits, perks, etc.)?

47 To what degree do job rewards (salary, benefits, perks, etc.) depend on high levels of motivation?

EXTENDED VIGILANCE

Vigilance is the ability to maintain one's attention on a specific subject or task over extended periods of time. For example, radar operators spend much of their work day looking at a radar display screen, attempting to detect anomalous events. It is not surprising that heavy vigilance loads often produce fatigue. The questions in this section are about the vigilance demands of your job.

48 To what degree does your work require extended vigilance, as defined above?

49 To what degree is vigilance distributed and traded off amongst team members? In other words, does everyone have to be equally vigilant at all times, or does the locus of vigilance shift among team members during task performance?

50 To what degree does required vigilance produce fatigue in your job?

SECTION III: DECISION MAKING

The third section of the survey is about decision making. Jobs typically involve one or more components of decision making: assessment, diagnosis, prescription or planning, execution, and evaluation. Some jobs require skill in each of these elements.

We are interested in the performance of your work, in contrast to any preparation for performance you may do. For example, performing arts typically involve assessment, diagnosis, and planning in the rehearsal phase, but not in the actual performance. By then, the decisions have typically been made and all that is left is execution and evaluation of the performance. Other jobs, e.g., a physician's practice, involve all five elements throughout job performance.

We want to ask you questions about the elements that are part of your job. To do that, we need to specify which of the five elements listed above (assessment, diagnosis, prescription or planning, execution and evaluation) is part of your work. Please indicate which of the elements are involved in your work by checking the appropriate boxes.

Assessment
Assessment is finding out what is going on: Identifying the status or state of the important aspects of a situation. For example, physicians assess a new case (situation) by finding out what symptoms an ill patient is experiencing. Similarly, fire fighters gather information about wind, extent of fire, substance being burned, etc. in assessing a fire. Assessment can be thought of as information or data gathering in the initial phases of dealing with a situation. It is different that diagnosing the problem. Diagnosis is concerned with determining the source of the problem (and will be covered next). Please note that we are not interested in assessment that occurs during practice, rehearsal, or job training. We are only interested in assessment that occurs during actual job performance.

Does your job performance involve assessment? If so, please check the following box.
_____Yes, a significant part of my job involves assessment.

Diagnosis
Diagnosis, as indicated above, amounts to identifying the cause of the problem. After gathering sufficient data in the assessment phase, doctors diagnose diseases. The fire fighter will also gather necessary information to determine the source of the fire, which is important to knowing how to attack it. Does the fire involve hazardous chemicals, is it likely to move fast, what direction will it take? Again, we are only interested in job performance, not training, education, or rehearsal.

Does your job involve diagnosis? If so, please check the following box.
_____Yes, a significant part of my job involves diagnosis.

Prescription and Planning
The third element of decision making is to create a prescription or plan for treating a problem. In this phase, the physician decides what drug or other therapy to give a patient. The fire fighter determines how he or she will contain and stop the fire and what resources to use in doing so. Again, we are only interested in job performance, not training, education, or rehearsal.

Does job performance in your field involve planning and prescription? If so, please check the following box.
_____Yes, a significant part of my job involves planning and/or prescription.

Execution
All work endeavors involve some type of performance. Execution, the fourth phase of decision making, is when that performance takes place. A doctor might perform a surgery or administer the prescribed therapy. Fire fighters would distribute resources (water, chemicals, vehicles, manpower, etc.) to fight the fire.

There are wide variations in execution. For example, if your job involves generating a plan but other people actually execute it, then the execution portion of your job may be extremely simple, and you would not answer the questions in this section. On the other hand, if significant skill is required for good execution in your work (if some

people are clearly better at it than others), then you should answer the questions in this section.

Does your job involve significant execution? If so, please check the following box.
____Yes, a significant part of my job involves execution.

Evaluation
Evaluation is sometimes performed after a job is finished. In this phase of decision making, workers evaluate how well and/or how poorly they did on various aspects of the job. Sometimes the evaluation is done by supervisors and sometimes it is completed by the workers themselves.

We are interested here in post-action evaluation. In most work, there is another kind of evaluation that goes on all the time, namely checking whether appropriate progress is being made toward the goal. We will ask you about that later, but for now we are just interested in post-action evaluation.

Must you or do you typically evaluate job performance when it is completed? If so, please check the following box.
____Yes, a significant part of my job involves evaluation.

TASK PROCESSES: ASSESSMENT

In this section, we are concerned only with assessing a task situation—determining what is going on. We defer consideration of diagnosis (understanding the causal source of the situation) to the next section. We know it is often hard to draw a sharp line between assessment and diagnosis, but ask that you attempt to do so as you answer the following questions.

51 What level of skill does assessment require?

52 To what degree are the surface features indicative of the deep structure? Said another way, is what you see really what there is, or do you have to look below the surface?

53 To what degree are there significant irrelevant or deceptive features, things that are easy to see but are misleading about the real situation?

54 To what degree do small details influence assessment? Said another way, is the big picture the main thing, or can the entire situation change with a single detail?

55 To what degree are misleading or confusing pieces of evidence the result of antagonistic intention? Is it necessary to consider evidence with suspicion of intentional deception?

56 To what degree is there typically more than one way to frame a situation? "Framing" is just the way you look at a problem. For some tasks, the way to look at a situation is clear right away. For other tasks, figuring out which way to look at a situation is a big part of assessing it.

57 With what degree of frequency are avoidable mistakes made in assessing a situation?

58 To what extent can probes be made to confirm/disconfirm an assessment? A probe is simply any method for testing whether an assessment is correct prior to starting work.

59 How often do you have to choose a course of action despite not having a complete assessment?

TASK PROCESSES: DIAGNOSIS

As noted previously, diagnosis is identifying the cause of the problem. Physicians identify the physical problem or disease, and police officers determine if an erratic driver is driving under the influence. If your job performance does not involve a diagnosis please do not answer the following questions. We are concerned only with job performance, not training, education, or rehearsal.

60 What level of skill does diagnosis require?

61 To what degree is the evidence upon which a diagnosis is based frequently or importantly ambiguous?

62 To what degree must multiple hypotheses be considered concurrently? Said another way, are there many different reasons that a situation could be as it is?

63 To what degree is there typically more than one way to frame a diagnosis (e.g., to decide which factors are significant in a particular case)?

64 With what degree of frequency are avoidable diagnostic mistakes made?

65 To what degree is there well-established theory or guidelines for most diagnostic decisions?

66 To the extent that there is an established theory or set guidelines for diagnosis, to what degree is application of the theory or guidelines straightforward?

67 To what degree is quickness of diagnosis required? How quickly must a diagnosis be made?

68 To what degree is deferring diagnosis in itself a significant action?

69 To what degree can you be certain of your diagnoses?

70 To what extent can probes be made to confirm/disconfirm diagnoses?

TASK PROCESSES: PLANNING & PRESCRIPTION

The following set of questions pertain to the development of a prescription or plan for treating a problem. Again, we are only interested in job performance, not training, education, or rehearsal. If your job does not require planning or prescription during job performance, do not answer the following questions.

71 What level of skill does prescription (deciding what to do) require?

72 What level of skill does planning (deciding how to do it) require?

73 Once a diagnosis has been made, how many actions can be prescribed?

74 To what degree is planning or prescribing separate from and prior to execution, or is it normal to plan a little, execute a little, plan a little, etc.?

75 To what degree are prescriptions and/or plans explicit or tacit?

76 To what degree are changes in prescription or plan explicit or tacit?

77 To what degree does the evolution of plans vary between situations?

TASK PROCESSES: EXECUTION

Execution is actually doing the work involved in your job. The following set of questions ask about various issues associated with the execution of job performance.

78 What level of skill does execution (actually implementing the prescription or plan) require?

79 To what degree must multiple paths be maintained as possibilities during execution?

80 To the extent that multiple paths must be maintained, to what degree is the task leader mainly responsible for this, or must all team members be cognizant?

81 How important is timing in task execution? For example, for a musician, very small differences in when an entry is made have major effects on the quality of the performance. By contrast, for

an accountant, finishing the accounts by the end of the month may be the goal and the details of timing insignificant.

TASK PROCESSES: EVALUATION

The following section contains question regarding the evaluation of work completed. We ask about a variety of issues related to the evaluation of work.

82 How important a skill is post-event evaluation?

83 To what degree is evaluation formally encouraged or required?

84 To what degree is evaluation restricted by politics, reputations, or other constraints?

TASK PROCESSES: TASK METHODS

Based on your answers in the previous section, we assume that your work involves problem solving during task execution. Specifically, if you marked that you must assess, diagnose, and prescribe (or plan) before doing the actual work during task performance, then "problem solving" is part of your work. The following set of questions concern task-specific problem solving methods you may apply in your work.
85 To what degree are methods for problem-solving standardized?

86 To the extent that there are standard methods, how often are they actually applied in the field?

87 To what degree can decisions or actions normally be compensated for by future actions?

88 How significant to problem-solving is predicting the behavior of others?

89 How many tries does one normally have in attempting to solve a problem?

90 To what extent can you experiment while implementing a solution or plan? For example, in packing items into boxes, many arrangements might be tried. In building skyscrapers, on the other hand, the plans must be followed.

TASK PROCESSES: SOLUTION CHARACTERISTICS

As in the previous section (task methods), we assume that your job performance involves problem solving as part of task execution. This section of the survey contains question about the solutions that are developed as part of the problem solving effort. Solutions are the ways in which you treat the situation or problem. A mathematical solution would be an answer to a set of equations. A fire fighting solution would be the certified end to a fire. And so on. Clearly, some kinds of tasks have more clearly defined solutions than others.

91 How long after a solution is implemented is it apparent that it was correct or incorrect?

92 How frequently can solutions be proven correct?

93 To what degree can you trust solutions on their appearance? For example, the multimillion dollar Oakland fire grew from a small fire that appeared to have been successfully put out.

94 How often are solutions only be known to be satisfactory after they've been completely implemented?

95 How much do solutions vary in quality?

96 To what degree is it necessary to trade off the quality of a solution with other factors when constructing a solution?

97 To what degree do solutions have to satisfy multiple, not necessarily complimentary criteria?

98 How frequently does task performance require proceeding despite the presence of only a partial solution?

TASK PROCESSES: UNCERTAINTY

Uncertainty is a factor in many kinds of work. For example, police officers never know what they will encounter on the street during their shift. At the other extreme, performers are typically well rehearsed such that very little is uncertain (other than crowd reaction!). Most steps are executed as planned. The following set of questions asks about the degree of uncertainty and how it is managed in your job.

99 To what degree are parts of the task intrinsically or unavoidably uncertain?

100 How often is significant data uncertain?

101 How often is knowledge incomplete or uncertain?

102 What degree of uncertainty is typical in deciding how to think about a particular situation?

TASK PROCESSES: SELF-MANAGEMENT

Self management is the continuous monitoring of one owns performance. Some jobs require accurate and continuous self monitoring, others do not. For example, dancers must continuously monitor their placement in time and location relative to other dancers and to the music. Soldiers, fire fighters, and police must continuously evaluate their effectiveness during their work. The following questions ask about the degree to which self-monitoring (also called self-management or metacognition) is important to your work.

103 How important is self-monitoring of decision and performance timing? For example, for some tasks, it is more important to make a decision at the right time than it is to wait until all of the possible data has come in.

104 How important is self-monitoring of fatigue or distraction as these affect task performance?

105 How important is self-monitoring of process involvement as this affects task performance? (Involvement issues might include maintaining a positive attitude, maintaining consistency, professionalism, or concentration.)

106 To what degree does task performance require frequents shifts of attention?

107 To what degree is the team or team leader frequently interrupted by external elements that are not task-related during task performance?

108 How difficult is it to maintain the thread of concentration while dealing with interruptions? In some tasks, regaining concentration after an interruption is not hard. In others, especially when many balls must be kept in the air at once, it can be very difficult.

KNOWLEDGE: FACTS

This section of the survey concerns the knowledge a worker must possess to perform his/her work effectively. Two types of knowledge are distinguished: knowledge of facts and information, and knowledge of procedures. Knowledge of facts is the ability to recall, recognize, or otherwise use information pertinent to the job. Knowledge of procedures is knowing how to do the task. The following questions are about knowledge about facts.

109 How large is the volume of facts to be known or recalled?

110 To what degree are there many facts that might apply to a situation, and part of knowing the job is to recall just the relevant ones?

111 How accurately must facts be recalled?

112 How quickly must facts be recalled?

113 To what degree do facts change over time? There are two reasons facts can change. One is, the state of affairs they

describe changes. For example, a treaty may expire, a market may close, or a resource may become accessible. The second reason is that the relevance of a "bundle" of facts may change. For instance, an artillery commander needs to know the range and accuracy of the enemy's guns. If the opponent changes to a new gun and eliminates the old, then the facts about enemy gun range and accuracy may change completely. (Even though the old facts are still true, they are no longer relevant.)

114 What proportion of facts must simply be known, in contrast with facts that can be inferred with reasonable accuracy? For example, you either know your mother's maiden name or you don't. It can't be guessed based on other evidence. On the other hand, when a fly ball will hit the ground can be guessed pretty accurately.

KNOWLEDGE OF PROCEDURES

A procedure is a step by step sequence of actions that must be performed to complete a task. As noted in the previous section, procedural knowledge involves knowing how to execute task steps. For example, maintaining a valve in a power plant typically requires dismantling, inspecting, cleaning, repairing components, replacement of parts, and putting the valve back together. Together, the task steps constitute a procedure, for which skill is required at just about every step along the way. Knowing how to execute each component is procedural knowledge. The following questions ask about procedural knowledge that may be relevant to your work.

115 To what degree are step by step procedures part of the task?

116 To what degree does good performance require selecting the right procedure from among many possible procedures for the particular circumstances? That is, figuring out the right thing to do?

117 What level of skill does the execution of procedures require? That is, once you know what to do, does it take a lot of skill to actually do it?

118 To what degree does one have to anticipate the next step when performing a procedure?

119 To the extent that anticipation is important, to what degree does that include knowing how others are going to behave or react and adjusting accordingly?

120 To what degree is having the right attitude an important part of performing task procedures? For example, in some tasks, stress, or physical or emotional fatigue tends to lead to reduced efforts.

121 To what degree do the procedures have a substantial physical component? Examples include marksmanship, surgery, and musical performance. Accounting, by contrast, does not make strong demands on physical skill.

SECTION IV: TEAMWORK

This section of the survey asks questions about how teams operate in your work. The eight subsections address different aspects of teamwork including communication, monitoring teammates performance, evaluative feedback, backup, team membership, interdependence, shared skills, and the stability of the team. When answering the questions in this section, please consider how the team functions as a whole. We are not so interested in any single team member's role in the team or how that individual interacts with his/her teammates. Instead, we want to know how all of the members interact in general.

TEAM MUTUAL MONITORING

Some teamwork requires that team members closely monitor each others performance on the job. In some cases, continuous monitoring is critical to the task because the actions executed by one team member entirely depend on another teammate's work. For example, to make a shot in basketball players must be passed the ball by their teammates at an appropriate point in the game. In this case, both the recipient of the pass and the passer must be continuously monitoring each other's and other players' locations. Sometimes members' roles are more independent, and can be performed in isolation without much monitoring of teammates, e.g., factory worker roles in an assembly line. In this section, we ask questions regarding the degree of team monitoring necessary to your job.

122 How important is monitoring teammates behavior to task performance?

123 To what degree are teammates expected to monitor each others' actions for correctness and/or timeliness?

124 To what degree must teammates know whether teammates are in need of assistance?

125 To what degree do team members monitor whether appropriate progress is being made toward the goal of the team?

126 How difficult is it to monitor teammates' performance?

127 To what degree does rapid change in the situation affect teammates' ability to monitor one another?

TEAM FEEDBACK

Feedback is information that a worker receives about the quality and adequacy of his job performance. Sometimes feedback is provided by equipment or the environment is which the task is being performed. For example, a musician immediately knows by the sound of the instrument whether he/she has correctly performed a musical piece. In other cases, feedback is provided by team members. The questions in this section addresses the type of feedback that is given to team members by their teammates or leaders. As such, the type of feedback we are concerned with is a form of communication among the individuals on a team. When answering the questions in this section, please think of how teammates communicate information about each other's performance.

128 How important is giving feedback to teammates to effective task activity?

129 How important is receiving feedback from teammates to task activity?

130 To what degree is feedback used during task performance to keep performance on track?

131 To what degree is feedback direct among team members?

132 To what degree is feedback mediated, e.g., through a mutual superior or in some other way?

133 To what degree is the flow of feedback typically influenced by differences in status, tenure, or rank among team members?

134 How explicit is feedback? Or, is it implicitly communicated (e.g.,

via attitude, degree of cooperation, physical postures, etc.)?

135 To what degree might team members expect reprisal for giving unwanted feedback?

136 How formalized are the procedures for giving and receiving feedback?

COMMUNICATION

Communication among team members can be verbal or non verbal. In either case, information about the work itself or about other teammates is conveyed. This section contains just three questions about how communication occurs among teammates in your work.

137 To what degree is communication among team members an "open channel"?

138 To what degree is there a strong communication requirement to "close the loop" (confirm correctness or appropriateness) during task performance?

139 How much task-specific jargon or non-verbal language is needed to effectively communicate?

TEAM RECIPROCAL BACKUP

Teamwork often entails "backing up" a teammate's work when his or her performance drops or when it is not possible for a single individual to complete the work. For example, a soldier might take over another soldier's responsibilities when an injury occurs. Teammates may simply provide assistance during backup, or they may completely take over the task. Reciprocal backup refers to the degree to the team members provide backup for each other. This section contains questions about reciprocal backup in teams you belong to as part of your work.

140 To what degree is reciprocal backup an important part of task performance?

141 How important to confidant task performance is knowing that one will be backed up ?

142 How common is actual active backup in the field?

143 How welcome are team members to jump into other team members' subtasks if they perceive a need?

144 How comfortable are team members typically in accepting others' assistance?

145 To what degree is there a common set of guidelines, practices, or conditions where backup is called for and expected?

146 How frequently do team members have to anticipate others' need for backup?

147 To what degree do team members have to change their performance to help teammates avoid a future need for backup?

TEAM MEMBERSHIP AWARENESS

This section of the survey contains questions about team spirit and the degree to which team members have a shared awareness of the team as a single unit. In many situations, it is very important that the team members develop a sense of working together, of belonging to something larger than oneself, and devotion to teammates. For example, soldier training attempts to develop a cohesiveness among members of units so that when they are faced with adverse situations they will work as a single entity. The degree to which membership awareness affects teams varies among different types of jobs.

148 To what degree does esprit du corps affect quality of team performance?

149 To what degree is there a "culture" of team membership, e.g., uniforms, physical separation of team members from others,

special tokens, special treatment?

150 How explicit are expectations for team obligations?

151 How explicit are expectations for team benefits?

TEAM INTERDEPENDENCE

This section of the survey contains questions about interdependence among team members. Interdependence in a team is the degree to which the overall team performance depends on how its members perform together. For example, many athletic teams (basketball, soccer, etc.) do not function well when team members focus on their own performance and ignore the performance of the team as a whole. By contrast, the performance of a track or a gymnastics team is simply the sum of the scores earned individually by each of its members.

152 In your work, to what degree do team members typically adjust their own performance and blend themselves into the team to get the best overall team performance?

153 What proportion of team members are typically willing to accept interdependence?

154 How important is confidence in teammates?

155 How typical is confidence in teammates?

156 To what degree are different parts of the task mutually interdependent while they are being performed? For example, in a musical group every player must continually synchronize with all the others. By contrast, in some factories team members are not aware at all of what other team members are doing.

157 To what degree is support from teammates important in generating high levels of motivation?

158 To what extent does the nature of the task encourage interdependence?

159 To what degree does the work culture support interdependence?

TEAM SHARED SKILLS

In some teams, all of the roles that members can take are identical. Each member must have the same set of skills as every other member. In other teams, each member has a very different role that no one else can do, and the skills he/she must possess may be quite different. The members of some teams may have such different skill requirements for their respective tasks that their understanding of the work is completely different. For example, surgery teams have members (e.g., anesthesiologist, surgical nurse, surgeon, attending physician) whose knowledge and skills are quite different and complementary. The questions in this section of the survey ask about the skills that are held in common and the skills that are different among teammates.

The following questions are not about degree of skill. We are concerned here only with whether one or many team members have a particular skill, not with their relative competence We are not interested here in who's the best or worst driver on the team; only, how many team members can drive the truck?

160 How similar are teammates' understanding or "mental model" of the task?

161 What proportion of team performance skills are held in common by all team members?

162 How important is it for team members to know what their teammates are going to do?

163 To what degree do teammates share or trade physical tasks during task performance?

164 How common is active mutual encouragement among teammates during task performance?

165 To what degree to teammates share intellectual tasks during task performance?

TEAM STABILITY

This section of the survey contains questions about turnover within teams as well as other issues of stability. Teams vary in how long they are composed of the same team members. Also, they vary in how often the roles are restructured or reorganized. For some jobs, team roles must be loosely organized so as to adapt to constantly changing situations. For other jobs, a single organization usually suffices. Membership stability refers to issues of turnover as well as frequent changes in organization.

166 How long do teams typically stay together?

167 How important is trust in other team members' competence?

168 How common is it for teamwork style to change according to the situation? For example, in one situation, a clear and commanding leader may be needed; in another, a more organic group adaption is appropriate; and in a third a democratic approach might be best.

169 What degree of autonomy do subteams have to organize themselves to get the job done?

SECTION V: ERRORS

This section of the survey addresses errors that are made on the job. Different types of errors occur in different jobs. For example, some mistakes are physical in nature, e.g., a bolt is dropped into a valve a during maintenance task. Other errors are mental,·due to mistakes of decision or judgment. Each of the four subsections of this component of the survey corresponds to a different type of error.

TYPICAL ERRORS: PHYSICAL DIFFICULTY

Physical difficulty in tasks often result in physical errors. For example, the potential for error increases when tasks must be performed quickly, with great strength, or with great precision. This section of the survey contains questions about the physical demands of your job and the consequential errors that result.

We are interested in typical errors. There may be some very infrequent errors that are particularly notable because they have important consequences, but in his section we're concerned only with the typical patterns of errors that are most commonly seen.

170 What proportion of the physical parts of the task must be performed at very high speed?

171 What proportion of the physical parts of the task must be performed with very high precision?

172 How serious, typically, are the consequences of physical errors?

173 To what degree can physical errors be repaired or compensated for?

TYPICAL ERRORS: FATIGUE

Fatigue can occur from lack of sleep, high levels of physical exertion, low to medium levels of physical exertion over long periods of time, mental exertion, or emotional stress. Each of these types of fatigue

has the potential to increase the likelihood of error on the job. The questions in this section address issues of fatigue and error that might occur in your job.

174 What kind(s) of fatigue are common? Please check all that apply.
General physical
Physical overuse
Emotional
Mental
Sleep deprivation
Cumulative stress

175 How often must the team perform the task when fatigued?

176 What degree of fatigue is common?

177 How commonly does morale fatigue occur?

TYPICAL ERRORS: MENTAL

Mental errors can be distinguished from physical errors in that they are largely mistakes in judgment or decision. Not only are poor judgement and wrong decisions included in this category, but errors of anticipation, of failure to anticipate, of incorrect or inadequate assumptions, or of misestimation are all examples of the range of mental error of interest. The questions in this section address decision errors that might occur in your job. Again, it is the typical errors that are of interest.

178 How common are decision errors?

179 How avoidable are decision errors?

180 To what degree is there a clear consensus on what is and is not an error?

181 To what degree are errors, their causes, and their resolutions freely discussed?

182 How often must team members switch among subtasks when performing the task?

183 How easy is it to discriminate between real error and differences in opinion or judgement?

184 How often do erroneous beliefs arise and take root?

185 How easy is it to identify patterns of common errors? ("Rookie" errors might be an example.)

TYPICAL ERRORS: SELF-MANAGEMENT

Efficient and effective work toward a goal requires self-management. Self-management involves knowing when progress toward the goal has been achieved, the relative contribution of that progress, the direction of the progress, and what other work must still be completed. In some jobs, it is possible to erroneously believe that a solution has been reached, when in fact the problem still exists and its symptoms are only being disguised or masked. For example, a physician may withdraw his or her attention from a patient when initial signs of improvement appear and fail to notice the indicators of recurrence that would have been obvious if the right amount of attention had been paid. This type of error is a mistake based on a poor mental allocation of attention, that is, poor self-management. The two questions in this section address mistakes in self-management.

186 How frequently is a short-term "patch" mistaken for real long-term task completion?

187 How frequently do team members or the team as a whole focus so much on a current subgoal that the overall goal suffers?

SECTION VI: TASK LEADERSHIP

In this last section, we ask about leadership. For some kinds of work, leadership is an essential and important part of team performance. For other kinds of work, it is much less prominent. In the following questions, we ask about the role of leadership in your job. As with all of the other sections of the survey, please think of job performance, rather than preparation, training, or rehearsal.

Task leadership is an important component of many jobs that require teamwork. Leadership qualities include motivational, managerial, organizational, and technical abilities, as well as others. Leaders vary in how well they do their job. This final section of the survey asks you about leadership in your work, especially as it is relevant to teamwork. If your team does not typically have a leader, do not answer the following questions. Instead, mark each question "N/A" or simply skip answering.

188 How thoroughly does a team leader have to know the function or utility of subordinate's tasks, that is, what and how the tasks contribute to the overall goal?

189 How thoroughly does a team leader have to know subordinate's tasks with respect to their performance, that is, how to actually do the task himself or herself?

190 How often do team members typically perceive and respect their team leader's knowledge?

191 How often are team leaders perceived as being willing to listen?

192 How often do team leaders themselves display good team behaviors (helping out, giving and receiving feedback, displaying attitudinal interdependence, etc., that is, leading teamwork skills by example)?

193 How much variability is there among team leaders in approach to feedback and guidance?

194 How easy and straightforward is it to judge the effectiveness of

leadership?

195 How many different leadership styles are used for the task (e.g., the tough style, the cheerleader style, the lead-by-example style, etc.)?

196 How common is micromanagement?

197 How aware is the leader, typically, of his or her level of performance?

198 To what degree is there direct feedback on leadership effectiveness?

CRITIQUE OF THE SURVEY

A few words about the intent of the survey and the assumptions underlying it. We believe that teamwork is not yet well-understood, and that the underlying processes need to be better illuminated. Is the teamwork evidenced by a fire crew the same as the teamwork displayed by a jazz quartet? Are the differences simply a matter of different degrees of emphasis or development of the same set of underlying psychological components? Or are different components involved? Unlike more specific psychological phenomena, image recognition for example, we (as a research community) are not yet in the position of being able to articulate the components of interest in an exact and exclusive way, and to make precise measurements of them. In recognition of this, the survey intentionally sweeps with a broad brush, hoping to be as inclusive as possible. The goal of the attempted inclusiveness is to capture what is common between different kinds of teamwork, and if possible to identify what is not common.

Precise surveys are only possible when you have a clear statement or decision to analyze, and when you meet the important additional condition that you have a denumerable (and manageably small) list of alternatives from which to choose. In AI jargon, this is a "structured selection" problem. You can't perform a structured selection, though, until you've bounded the space and enumerated the alternatives.

With respect to teamwork, the training research community has not yet done that. Studying training is much more what's called a "constructive" problem, i.e., a process of taking candidate components or ideas, trying out different combinations and arrangements, and exploring the space of possibilities with the expectation that an increasingly focused picture will (eventually) emerge. This is a bit more like art than science, or put another way, more like design than like implementation. Surveys are not nearly as apt for constructive problems as they are for structured selection (unless you allow essay questions, which pretty much obliterates precision). Our goal with the survey is to provide data points useful to bounding the problem space of teamwork and contributing toward understanding its internal structure.

There can be no doubt that, ideally, we want our questions and stimuli to be as specific as possible, so that each respondent has an identical understanding of the meaning of each question. Otherwise, a single question can end up being different questions for different respondents. Then how could we make sense of the results? Empirically, though, we ran sixty people and none of them had trouble answering the questions. So the evidence is suggestive that the questions resolve to single, strongly preferred interpretations.

Most surveys are more precise than the one we've created. The problem is not that we're sloppy, unscientific dummies. The problem is in what we're trying to do. My belief is that imposing clear, crisp distinctions on teamwork at this point would be artificial: It would assume more knowledge than yet exists, and would therefore be bad science.

The most serious criticism of the survey was offered by Angelo Mirabella, Ph.D.: "Inadequate effort to insure that the respondent establishes and maintains a well-defined, consistent frame of reference." This is a powerful critique. The problem is, some tasks have well-defined categories of episode that can productively be adopted as a reference point in answering the questions, and some don't. For example, the "incident command of a multi-alarm fire" is a clear subcategory of fire command. But for an emergency room physician, so many such categories exist, each with so many variations, that to constrain the questions to a single incident or category of incidents would be to arbitrarily and, to my mind, not very sensibly restrict the doctor's freedom to describe her work. Worse, it would give a false reading of what she actually does—Her wide range of tasks is an *essential* element of her work.

Even within a nicely defined task, competitive basketball, for instance, such strong frames of reference might or might not be useful. Using the basketball example, risk acceptance may be significantly different in the fourth quarter than the first, if your team is ahead or behind (and by how much), if it's the regular season or the playoffs, if it's the first game of the playoffs or the last, and so on.

The frame of reference problem came up over and over again as we designed, and redesigned, and argued about the survey. Do we

restrict to a single incident, or to a single category of incident, or do we try to make our intentions clear and leave it to the respondents to decide whether one event or category of events, or the entirety of their duties should be the base from which they draw in answering questions?

We chose the more general, less restrictive approach. I believe that as a research community, we are still in the process of "successive approximation" in studying teamwork. Methodologically, it would be much nicer to have crisp and unambiguous boundaries. But because we do not yet know enough about teamwork to impose strict boundaries without risking a self-validating survey, we chose to hew to the generalist approach.

One further factor pushed us in the direction of leaving it up to the respondent to decide. We were aware that in some kinds of teamwork, an intrinsic part of the job is to perform multiple, disparate subtasks concurrently, and to dynamically negotiate and trade responsibilities for these subtasks among team members. Our ER doctor is one example of this sort of task; nursing is another. (Because competence in such load-balancing and load-sharing is a critical element of effective teamwork in nursing, it is highly germane to nursing training.) We did not want to artificially limit respondents with these sorts of multitasking kinds of work.

The establishment of a firm and clear frame of reference, and also, more importantly, providing a survey instrument that can be sensibly used by multiple populations runs into the problem of the degree to which one size can fit all.This is called in the AI world the "strong methods/weak methods" problem, and has been discussed since the 50's (an outgrowth of seeing the limits of Newell & Simon's General Problem Solver).

A "strong method" is one that is completely specific to a class of problem and is known to generate an accurate answer. A "weak method" is one that is very general and can be applied over a range of problems. If you have a linear optimization problem, linear programming is a strong method, and of course is to be preferred. On the other hand, if you have a medical prescriptive problem, strong methods do not exist, so the issue is which weak methods you apply, when and how.

The more tightly you can focus a problem, the more likely you are to find a strong method. On the other hand, the more tightly you focus a problem, the narrower your view, and the less broadly useful are either your methods or your results. Since we wish for broad coverage, we wrote questions amenable to a broad range of answers.

While strong methods might seem desirable, had we in fact used a much more tightly focused approach in the survey, we'd be guilty of pre-fitting what we wish to study. Since we want to see what kinds of patterns of teamwork emerge, a tight focus would have forced us to make a number of strong assumptions about what we were going to see prior to asking our respondents. You only get a strong focus if you have a strong framework. I've expressed my belief that the framework for studying teams is immature. Therefore, it seems to me it would be difficult to narrow the focus without biasing the survey toward our own preconceptions. To avoid this, we had to write a more general instrument.

As teamwork becomes better understood and more empirical data is gathered, stronger, more focused research will be possible. Based on our reading, though, teamwork is not well-understood yet, and therefore a more narrowly focused survey would run the risk of being self-validating.

To bring this back to the specific question, whether to answer as an individual team member or on behalf of the team as a whole, the question is, how different are the answers between the two perspectives?

Many questions are unaffected by the distinction, i.e., questions about the nature of the task and processes ("Once a diagnosis has been made, how many actions can be prescribed?") Many more questions simply require one or the other perspective ("To what degree does esprit du corps affect quality...?"; "How motivated, typically, are team members...?")

We are left with circumstantial and outcome questions ("To what extent is the physical environment in which the task is performed fast-changing?"; "How long after a solution is implemented is it

apparent that it was correct or incorrect?") When there are significant circumstantial or outcome factors that vary widely between team members, then the answers may differ between the individual and the team perspective.

We don't think the difference is significant. We rely on two interrelated assumptions: (a) coherent team binding; and, (b) respondent representativeness. In coherently bound teams, the circumstantial and outcome factors to which the distinction applies will be perceived as shared. It's the team that takes the floor, the team that wins or loses. This is nearly definitional: If circumstantial factors are not perceived as shared, the team will not experience itself as coherently bound. (Do employees of large companies feel they are on the same "team" as their CEO?) We also assume respondent representativeness, that the person completing the survey is a "regular" team member. We intended this when we developed our definition of team membership, which was constructed to explicitly exclude individualistic interactions and, in general, "external" team affiliates. That a person or role is necessary to team functioning does not mean that person or role is directly part of the team. Coaches and commanders are explicitly excluded, unless they actually participate with the team in the field. (They can be part of coaching or command teams, of course.)

In one very specific criticism, the question, "How much do solutions vary in quality?" is thought to be ambiguous with respect to (a) variation in solution quality between alternative solutions to a single problem or episode, or (b) variation of solutions for a category of problem.

We believe these alternatives are less different than they appear to be on the surface. For a mathematical equation, there typically are either only one or a small number of correct solutions. (There are multiple solutions to Einstein's equations for General Relativity, for example.) Because this is true for all mathematics, distinguishing between a particular problem and a general class of problem is not especially useful, because the "quality of solution" answer is the same either way. At the other end of the spectrum, for some kinds of design problems, the solution space is huge, and there are always wide variations in solution quality. So here as well distinguishing a specific problem and a class of problem doesn't generate significant

useful information, because again the answer is the same either way.

What about intermediate problems, like medical diagnosis or military situation assessment? When we consider solution quality in these cases, we are probably really considering uncertainty. (On the assumption of the competent practitioner: The population of competent practitioners would quickly converge on a small number of interpretations, but would vary in their solutions according to the uncertainty of the situation.) But since throughout the survey we ask and encourage the respondents to discuss how things usually are, and to skip the boundary cases except when we explicitly ask for them, then the answer for a typical specific situation (with typical uncertainty) should map isomorphically to the answer for the class of situation. Again, we end up with the same answer.

I believe that we unconsciously include the nature of solutions as a priori conditions for our notions of what comprises a task, i.e., the perceived nature of solutions is part of the task bounding process. We don't classify a medical question like "do implants cause connective tissue damage?" with one like "how long should life be prolonged in extreme cases?" Though they both refer to medical issues, the kinds of solutions they have are so different we automatically put them in different conceptual bins (epidemiology and medical ethics, respectively). If an epidemiologist takes the survey, we would expect him or her to answer questions with respect to epidemiology, not medical ethics.

My view is that the study of teamwork is not mature and that we have no choice but to deal with many concepts that are, at this point at least, ontologically vague. Perhaps my view is too heavily influenced by my background, but it is difficult for me to accept that the precision that exists in computer science concepts like "efficiency of queuing mechanisms" or "optimal search of balanced binary trees" can be found in teamwork concepts like "monitoring", "vigilance", or "reciprocal backup." Some psychological concepts are elegantly precise, but it doesn't appear to me we're there yet with teamwork. Because there is a far larger range of subject matter crammed into our current conceptual vocabulary for teamwork than there is for balanced b-trees, we are less ready to impose the precision available in logic or programming to the psychological objects of our study.

The movement over the past twenty years in making psychology more precise is impressive, and my expectation is that the coming twenty years will see even more progress, especially as we integrate neurophysiology and artificial intelligence results into the field. When we have reached that degree of precision in the study of teamwork, then the generalist approach we have adopted in the survey will be obsolete. But it is my belief that we have not yet reached that state.

RESPONDENTS

Sixty subjects participated, in the following categories:

Athletics (19)
Engineering (3)
ER medicine (MDs) (3)
Firefighting (6)
Improvisational music (3)
Marines (6)
Nursing (6)
Police (3)
Teaching (team) (3)
Writing/editing (3)
Other (5)

We recruited a minimum of three subjects in each area in order to be able to check intersubject reliability.

INSTRUCTIONS GIVEN TO RESPONDENTS

Following, verbatim, are the instructions given our subjects.

We—the authors of the survey—are trying to better understand teamwork. We consider "teamwork" to be any activity where (a) people work together toward a common goal; (b) members know that they are members of a team and know who their teammates are; and (c) team members must interact during the work in order to achieve the goal. Your answers to the following survey questions will help us understand the nature of teamwork in your area of expertise.

The questions are grouped into seven categories: conditions, the structure of your task, decision-making, knowledge, specific teamwork issues, typical errors, and the role of leadership.

Examples of the kinds of teams we're interested in range pretty wide: sports teams, firefighters, military units, jazz musicians, software project groups, emergency room teams, and many many others.

The only restriction we place on whether someone should be considered part of the team is that interactions between the person in question and the rest of the team go both ways. A coach would not be considered part of an athletic team. Nor would a symphony conductor be considered part of the orchestra, nor a Battalion Commander part of the battalion team. The Battalion Commander and his or her staff would be a team, though, as would a conductor and a composer, or a player-coach of an athletic team. The distinguishing feature is the interplay between team members. If it goes in both directions, then the person is (by the definition we use in this survey) a team member. If it only goes one way, e.g., as in issuing orders or directions, then even though the person may be necessary to the team's functioning, he or she is not considered a team member.

Taking the survey is simple. You simply circle the number that seems right to you on each scale. Most questions only want one selection, so if you make a mistake or change your mind, just cross our your original answer and circle the number you now think is most accurate.

If a question doesn't really pertain to your work, you can always circle "Not Applicable" ("N/A"). Please answer only the questions that make sense to you. You can always pass a question by; you never have to answer a particular question.

Each question is presented with two "anchor points," written below the scale. These can be thought of as the boundaries for the range of answers to the particular question. We've typically made the ends of the scales pretty strong statements. That's so if something is really true about your work, you can tell us. Don't be shy about making strong statements. At the same time, try to be realistic in your answers.

HYPOTHESES

We generated and tested three hypotheses about relationships between task elements and teamwork and leadership.

Teamwork
Hypothesis 1.
Stressful and/or dangerous environments are strongly correlated with high scores on the teamwork issues of mutual monitoring, reciprocal backup, and esprit du corps.

Mutual monitoring is highly correlated with a physically stressful environment, $r = .556$, $p < .0001$.

Reciprocal backup is highly correlated with a physically stressful environment, $r = .538$, $p < .0001$.

Esprit du corps is highly correlated with a physically stressful environment, $r = .558$, $p < .0001$.

Mutual monitoring is highly correlated with a physically dangerous environment, $r = .345$, $p < .01$.

Reciprocal backup is highly correlated with a physically dangerous environment, $r = .538$, $p < .0001$.

Esprit du corps is highly correlated with a physically dangerous environment, $r = .521$, $p < .0001$.

Leadership
Hypothesis 2.
Seriousness of outcome is strongly correlated with respect for a team leader's knowledge and with his or her modeling of teamwork behaviors.

Seriousness of outcome does not appear to be correlated with a team leader's knowledge, $r = .189$, $p > .1$.

Seriousness of outcome does not appear to be correlated with a team leader's modeling of teamwork behaviors, $r = .06$, $p > .1$.

Hypothesis 3.
Degree of uncertainty in the task environment is only weakly correlated with respect for a team leader's knowledge and with his or her modeling of teamwork behaviors. It is slightly more strongly correlated with the degree to which the team leader is perceived to be self-aware.

Degree of uncertainty in the task environment is correlated with a team leader's knowledge, $r = .353$, $p < .01$.

Degree of uncertainty in the task environment is correlated with a team leader's modeling of teamwork behaviors, $r = .270$, $p < .05$.

Degree of uncertainty in the task environment is correlated with the degree to which the team leader is perceived to be self-aware, $r = .385$, $p < .005$.

DISCUSSION

Hypothesis 1 claimed "Stressful and/or dangerous environments are strongly correlated with high scores on the teamwork issues of mutual monitoring, reciprocal backup, and esprit du corps."

Confirmation of this hypothesis is unsurprising - in tough and/or hostile environments, teammates stick together. With respect to mutual monitoring the evenness of the very strong correlation is mildly surprising in that high rankings were also given to that variable (mutual monitoring) by the improvising musicians, who did not rate their environments as particularly dangerous.

Hypothesis 2 claimed "Seriousness of outcome is strongly correlated with respect for a team leader's knowledge and with his or her modeling of teamwork behaviors."

Outcome seriousness did not correlate with either respect for a team leader's knowledge ar modeling of teamwork behaviors. This is a surprise. We had two subgroups who routinely deal with serious outcomes, doctors and nurses, and Marines, police, and firefighters. The two groups are very different with respect to leadership. Our two medical groups tend to be fairly (nurses) to highly (ER doctors) autonomous and collegial, while Marines, police, and firefighters are hierarchical command organizations. In a hierarchical command organization, leaders are not supposed to model teamwork behaviors; rather, they have distinct responsibilities which tend to be other than those of their subordinates. Thus, in retrospect, perhaps we should not have expected the command organizations to show the predicted correlation.

That doesn't explain the lack of correlation with respect to leader's perceived knowledge, though. A persuasive explanation is not ready to hand.

Hypothesis 3 claimed "Degree of uncertainty in the task environment is only weakly correlated with respect for a team leader's knowledge and with his or her modeling of teamwork behaviors. It is slightly more strongly correlated with the degree to which the team leader is perceived to be self-aware."

We didn't expect to find correlations on the first two parts of the hypothesis, but we did. The correlation is technically higher for the third part, but not substantively.

Our reasoning in proposing the hypothesis was that external factors (degree of uncertainty outside the control of the practitioner) should show little correlation with team members views of their leaders.

Two explanations of our findings suggest themselves: Selection and attribution. Selection would occur if the uncertainty of the environment had the effect of making the selection of leaders more rigorous, such that those selected for leadership are genuinely deserving of their team's respect. Attribution would occur if the psychological pressure of uncertainty predisposed team members to attribute competence to their leaders, independent of evidence, simply as a way to decrease that pressure by forming the belief that they are in "good hands."

One potential measure to test this would be to develop some means of assessing volatility in assessment of leadership. If respect is genuine, then volatility should remain low despite temporary highs and lows in team performance. On the other hand, if it is a projection, we would expect a higher likelihood of abrupt reversal if team members felt "let down" by the leader, even if variations in team performance had nothing to do with his or her performance.

HOW TO FIGURE OUT WHAT YOUR TEAM IS REALLY DOING

People have been trying to figure out what is *really* going on for a long time. (Some have been more successful than others.) Psychologists have developed a number of task analysis methods in order that highly specific descriptions of jobs can be written.

In this section, we relate task analysis and cognitive task analysis techniques. First, we discuss task and cognitive task analysis for individuals, then for groups. Before doing that, though, some further orientation might be useful. We'll provide some general categories of tasks, then a progression of ideas about how tasks and their environments interact.

SOME VERY GENERAL KINDS OF TASKS

What do people do? There are many ways to group and differentiate kinds of work, and many taxonomies representing different perspectives. An approach that has been popular in cognitive psychology and artificial intelligence categorizes human tasks as either convergent or divergent.

Convergent tasks have ("converge on") one right answer. Manipulation, monitoring, identification, interpretation, diagnosis, and debugging are typically viewed as convergent.

Divergent tasks, on the other hand, may have many possible satisfactory answers. Prescription, design (which can be viewed as arranging objects under constraints), planning (similar to design, but arranging actions rather than objects under constraints), and rationalizing (explaining, describing, motivating, etc.) are all typically seen as divergent.

Generally, other common tasks, e.g., control, repair, configuration, scheduling, prediction, instruction, and evaluation, can be composed from the more clearly defined "basic" tasks listed above. As a rough heuristic, if the truth is in the world, the problem is probably convergent; if truth is in the mind, it's probably divergent.

TASKS-IN-PLACE: DISTRIBUTED REPRESENTATION

Interest in distributed representation comes from the insight that complex behavior can be accounted for by relatively simple mechanisms in a complex environment (Simon 1981; Brooks 1992), and the empirical fact that different representations of the same problem can have dramatic effects on problem-solving performance (Hayes & Simon 1977).

"Distributed representation" happens in problem solving when part of the way the problem is represented is internal to the problem-solver, and part is eternal in the environment. Two mathematicians solving a problem at a blackboard is an example. From this view, an external representation is not just a peripheral aid to cognition, but a necessary component of a distributed cognitive task. Zhang and Norman (1994) found five properties of external representation, as relevant to distributed representations:

1. External representations provide memory aids
2. External representations can provide information that can be directly perceived and used without being interpreted and formulated explicitly. This is consistent with Gibsonian affordances (Gibson 1979).
3. External representations can anchor and structure cognitive behavior, especially to the extent that the external representation is instantiated in physical structures and artifacts.
4. External representations can change the nature of the task as seen from the perspective of the problem solver, i.e., appropriate externalization of representation often makes tasks easier.
5. External representations are an indispensable part of the representational system of any distributed cognitive task.

In the past, task analyses took external representations to a greater or lesser extent for granted. Thoughtful examination of the distribution of representation is deserving of a prominent place in all kinds of task analyses.

TASKS-IN-PLACE: SITUATED ACTION

"Situated action" is the claim the cognition cannot be understood as a "thing" independent of the context in which cognition takes place. There is some persuasive evidence supporting this view:

- Independent Ericcson/Simon & Johnson-Laird results show that how hard a problem is often centers not on stack depth (how many things you have to think about) but on representational transformations (how many ways you have to be able to look at the problem). Changes in representation are closely tied to where and with what the problem is presented.
- Hutchins' work shows distribution of "cognition" and representation between people and their environment, and even more, that intelligent behavior cannot be accounted for (that is, is underspecified) except by looking at the human/environment system as a whole.
- Edelman proposes that the essence of intelligence is not in a applying, but in selecting (distributed) representation.

There is a lot more, all pointing to the essential nature of action-embedded-in-the-world, that the "inside the head/outside in the world" dichotomy is often misleading or even false. Situated action researchers claim that high-level human conceptual abstractions and extremely low-level material instantiations interact to produce behavior.

It would be hard to make a more commonsensical statement. Removed from academic language, all it says is, people live in the world, and that's where they do their thinking. For task analyses, it makes sense to direct attention to how the situation and the desired action interact, and how changes in the situation trigger new actions.

TASKS-IN-PLACE: ACTIVITY THEORY

Activity theory is the strongest expression of situated action. The two core notions of activity theory are:

- Mediation. "All human experience is shaped by the tools and sign systems we use. Mediators connect us organically and intimately to the world; they are not mere filters or channels through which experience is carried." (Nardi 1996)
- Consciousness. "Consciousness" is defined in Vygotsky's sense, that is, the unification of attention, intention, memory, reasoning, and language.

This is definitely a place where the specific methodological application of the concepts is critical, since people seem to feel fine about using the word "conscious" to stand for anything they want it to. (Exercise for the reader: List anything people do that can t be explained by reference to one or more of the attributes in Vygotsky's list.)

The thrust, then, of the methodological argument is that behaviors, both individual and especially group, are not just "embedded" in some physical artifact context. They are *essentially* intertwined. For that reason, the appropriate unit for analysis is the whole system, and decomposition should begin there. This is in contrast with traditional task analysis, which starts with the activities of each individual.

Not that activity theory minimizes the importance of the individual; according to Kaptelinin, activity theory insists on an essential asymmetry, focusing on the importance of motive and consciousness. Artifacts are mediators of human thought and behavior. This is slightly different than Hutchin's systematicity, but both clearly differ from both behavioral and cognitive psychology.

Nardi, Hutchins, and others claim this view yields analytic power not attainable by traditional task analysis. Task analysis is *post facto*, following practice (though it can lead to changes in practice). Currently, most artifact design, and training design for

that matter, is also in a sense *post facto*—it follows practice. In fact, we look at successful artifacts or training programs to understand why they work. If activity theory provides additional analytic or (especially) predictive power, then it is useful.

Task analysis and activity theory are complimentary. Activity theory that doesn't "bottom out" with specific, concrete actions is too vague to use. On the other hand, task analysis that doesn't understand the system of which the behavior of interest is an interwoven part relies on luck to make sense.

That may seem strong - particularly since we're about to describe task analysis in quite a lot of detail - but it's true to the extent that task analysis works best when the tasks chosen are sufficiently "compartmentalized" to minimize interactions with task context, and sufficiently non-symbolic to minimize cognitive implications of task steps. If either of the conditions is violated, task analysis is less effective. Stated in different words, the greater the role of tacit knowledge and behavioral fluency, the less effective is task analysis. Since the focus of task analysis is on articulating specific sets of well-defined steps that lead to a task goal, the hard part of task analysis, defining and selecting tasks to analyze, is left outside the method. Since activity theory seems to address this kind of issue, it is worth consideration for training design.

WHAT NEEDS TO BE UNDERSTOOD?

In the following sections, we distinguish behavior and cognition. As should be apparent, we believe this is a "distinction of convenience;" you don't really get one without the other. However, it is very useful fiction.

We will refer to behavior as what can be directly observed. Behavior occurs in steps, and all the steps can be observed and can reasonably be said to have a beginning, a middle, and an end. Changing a tire is a clear example of a behavior.

To a great extent, the structure of the task in the world determines the degree of behavioral binding. The nature and sequence of steps in changing a tire are almost entirely constrained by how wheels are attached to cars, and what wheels and cars are.

For traditional task analysis - which is very much behaviorally oriented - the best kinds of tasks are those for which there is only one way to do each step, only one way to sequence the steps, and it is always clear when the task is completed.

Always bearing in mind that the distinction is artificial, we'll call "cognitive" any task (or portion of a task) with non-observable steps. Reading a blueprint or a topographic map are examples of cognitive tasks. If a task involves interpretation, problem-solving, or prediction, it is cognitive.

An interesting element of cognitive tasks is that the performer-perceived difficulty of *doing* the task may not correlate very strongly with the difficulty of *learning* to do the task. For instance, some people are "social geniuses." They always seem to know the right thing to say, always make those around them feel comfortable and important, seem to thrive in any social environment, and so on. So, you ask them, "how do you *do* that?" and they respond, "Do what?" The sophisticated skills they display have been learned and developed unconsciously, and the performers' self- perception is of effortlessness.

Which raises a couple of important issues for analysis of cognitive tasks: Automaticity and identifiability.

Automaticity occurs in skilled performance when actions that once took thought have been performed so frequently that they get "compiled" into automatic responses that need no conscious awareness. This is very good for the performer, but very difficult for the analyst (namely, you). The reason: People don't necessarily know what they're really doing.

A case study will show the problems. Prospector was (is) a prominent mid-80's expert system for oil-field discovery. When it was first being built, the knowledge engineers focused on asking the subject matter experts (SMEs) how they did their job, then on building a system that did the same thing. Prospector was blessed with fabulous SMEs; one of them had written the primary text in the field. These were SMEs who could explain what they did with exceptional clarity, so the first version of Prospector was completed with very high hopes. Built by a highly competent team from the Stanford AI lab, it scrupulously reproduced what the SMEs reported that they did. It stank.

This caused serious consternation among the knowledge engineers, not surprisingly. Where had they gone wrong? The SMEs really were true experts; when they did the task, they got results. Why was the program so bad?

Confused but undaunted, they returned to the SMEs. Aware of work by Herbert Simon and Anders Ericcson on protocol analysis (which we'll discuss below as a cognitive task analysis technique), this time the knowledge engineers came to watch the SMEs work, video cameras in hand (and this was early-70's, well before camcorders were commonplace). Tapes in hand, they returned to their lab and performed a protocol analysis, an extremely painstaking frame-by-frame analysis of everything the SMEs were doing. After a large sweat investment, they hit the jackpot. In case after case, the SMEs had said that to make

decision A, they always looked at X. But examination of the tapes, measuring things like eye dwell on various parts of the SMEs' data screens, showed that when making decision A they barely glanced at X, but they never made the decision without looking carefully at the value for Y. The SMEs simply weren't aware that they were doing it.

Prospector was revised using the new knowledge, and it worked very, very well. The essence of the story is that sincere, committed, articulate SMEs, the very best in their field, told the knowledge engineers the wrong things. The SMEs believed that was how they worked; that was how the subject was taught, how it was written about in technical articles, how everybody knew it was done. It took extraordinary diligence and cleverness on the part of some very smart knowledge engineers to discover how it was really done.

The message for cognitive task analysis is not a simplistic "watch what they do, not what they say." After all, the explanatory component (what they say) is critical for many applications, and there is no *a priori* way to know the degree to which the SMEs in a particular field really can articulate the underlying processes. The lesson is more complex. Cognitive task analysis is a process of building a model of competence, and the criteria for success are empirical.

If knowledge is the core element of cognitive tasks, why not simply categorize task material with respect to the knowledge outcomes (as described in the section on The Nine Step Approach) and base decisions on training approach on the results?

The knowledge outcomes are problematic from two perspectives. First, it is not consistently clear what they refer to: The task, the cognitive process, or the result of the cognitive process. The name suggests the result, but the specific category names sometimes suggest the operation of the cognitive process (discrimination), sometimes what the process operates on (concrete concepts), sometimes the nature of the thing to be learned or applied (definitional concepts),

sometimes the formal representational structure of the knowledge (rules), sometimes the characteristic things people seem to do in managing certain classes of task (cognitive strategies).

But even if we take "knowledge outcomes" as fuzzy-but-usable concepts of things people do when they perform tasks (apply discrimination, execute rules, understand definitional concepts, etc.), are they then adequate as guidelines for selecting approaches to training?

Maybe yes, maybe no. John Anderson raises the identifiability problem: Membership in a given knowledge category can arise from multiple sources and have multiple implications, which category membership in itself does not specify. Said more simply, the same apparent cognitive behavior can arise from multiple sources, and you can never be absolutely sure you've identified the right one.

Figuring out the right one is significant for training, though. For example, many people we fooled by Joe Weizenbaum's ELIZA program (1969), which used a simple keyword pattern matcher to mimic a Rogerian psychotherapist. ELIZA appeared to show the same knowledge outcome as a real Rogerian therapist, but the "training" Weizenbaum gave ELIZA was drastically different than that one would provide any real therapist trainee. (By the way, Weizenbaum himself was appalled that people reacted as they did to his program.)

Taking another example, solving syllogisms. The research of Johnson-Laird and Wason is persuasive that these are normally solved with a "mental model," The mental model approach to solving syllogisms isn't very good (our cognitive capabilities didn't evolve to solve syllogisms), so people who want to become experts learn the Venn diagram approach, which works much better. But teaching the mental model approach and teaching the Venn diagram approach are different: The first implies repeated exposure, simple to complex, with feedback, and substantial memorization. The second suggests teaching

operationalization of a concept.

In general, the identifiability problem means that substantial experimental evidence is needed to support a strong statement about how people really solve cognitive problems. Even for the best studied areas, results are controversial (e.g., diSessa 1993) and often ambivalent (e.g., Patel et al 1993).

All of this doesn't mean cognitive tasks can't be taught! Just that it can be hard to get it right.

Behavior and cognition are complimentary approaches. Depending on the task, one, the other, or both may be appropriate.

ONE MORE THING: LEVEL OF SKILL

Before (finally) describing how the various kinds of task analyses, there's just one more thing. You do task analysis because you want to train some task. To decide how much and how deep a task analysis to do, you need to decide the target skill level.

This may seem to be pretty obvious, but it needs to be done with some specificity. After all, deciding how much cognitive task analysis to do, and when to stop, is itself a cognitive task. Unlike behavioral tasks, where you can usually tell when you're done, knowing when to stop a cognitive analysis requires an "external" criteria.

There are three steps: Determination of the planned trainees' current skill level, specification of the target skill level, and planning of the various kinds of analyses to bridge the difference. Analysis is difficult, time-consuming, and expensive. You want to do the right amount of analysis—The goal is training appropriate to need.

INDIVIDUAL TRAINING: BEHAVIORAL TASKS

There are a lot of different flavors of task analysis. Three approaches cover a fair amount of ground, and taken together provide reasonable coverage: Procedural analysis, fault-tree analysis, and performance analysis. Each in turn.

PROCEDURAL ANALYSIS

Procedural analysis is the most basic form of task analysis, the analysis of the observable procedure used to accomplish a task. The precondition for procedural analysis is that the task can be analyzed sensibly into behavioral steps that form a consistent sequence, that the sequence is straightforward enough that, once recorded, it can be followed, and that following the sequence will result in task completion and success.

There are five steps in procedural analysis:

1. Write down the terminal objective(s) and the standards of performance. Terminal objectives are just whatever is supposed to be accomplished. Performance standards can include completeness, speed, accuracy, efficiency, or other issues as applicable. If there are important intermediate objectives, do the same for each of them. Make both the objectives and the standards as specific and measurable as possible.
2. Find a competent task performer, in a real-world task environment.
3. Follow him or her around and record all of the task steps, in order. This step can be as simple as having the performer simply describe the task, or as elaborate as videotaping multiple performances and performing a protocol analysis on the content of the tapes.
4. Convert the recorded procedure into a step-by-step procedure description. Jonassen et al recommend reviewing these questions to determine whether you have done an adequate job: "Have all operation and decision steps been included in the outline? Have all branches from decision points been included? Is each step of the procedure a discrete step—that is, a separate action, and not part of the next step? Is the step size appropriate, and the same size across all steps? Are the steps described as observable performances?"
5. Test and validate the procedural description—Actually use it and determine what is left out, what is unclear, and so on.

To perform Step 5, the two additional analyses—fault-tree and performance—can be helpful.

FAULT-TREE ANALYSIS

Fault-tree analysis is, as its name suggests, an analysis of what can go wrong. First, we'll present "standard" fault-tree analysis, then a modified version that takes advantage of work already done in a procedural analysis.

Before continuing, though, a reminder that we're still in the realm of behavioral tasks—cognitive task analysis is a different (complimentary) activity.

Standard fault-tree analysis distinguishes three levels: Mission, function, and task. The mission is the purpose of the system, what the system under study does. The functions are how it does it. The tasks are how the functions are achieved. For instance, the mission of steam turbine maintenance is to keep the turbine producing power. The functions of maintenance are to examine and test the major components of the turbine at regularly scheduled intervals, and to replace components as necessary. The tasks are the steps necessary to examine, test, repair, and replace components. The advantage claimed by fault-tree advocates is that failures at the higher level can be analyzed at the level immediately below, and by doing this, a very thorough analysis can be achieved. Fault-tree analysis has up to nine steps.

1. Define the system, that is, the purpose or goals of the task and context in which it is performed, including relevant constraints.
2. Analyze the purpose, by listing the major functions of the system, then the subfunctions, and the objective tasks that accompany each of the subfunctions, and if appropriate the subtasks that comprise the tasks.
3. Identify undesired events or outcomes. What can go wrong, at each functional or task step?
4. Once a satisfactory list is compiled—"satisfactory" will be defined by your SMEs—faults should be ranked in three ways: order of (typical) occurrence, likelihood, and significance.
5. For each undesired event or outcome, the level (mission,

function, or task) of the fault should be determined and recorded.

6. Identify the failure "tree" leading to the undesired event or outcome. Do this hierarchically: If the failure is at the mission level, determine what functional breakdowns contribute to or cause the failure. If it is at the functional level, do the same with the tasks. It is important to distinguish at this point the failures that occur due to causes outside the control of the "system"—external factors that no change in proficiency of the operators (the people you're ultimately interested in training) could alter. These aren't "interesting" for the fault-tree analysis, since no change in performance will alter their occurrence. For each undesired event or outcome not eliminated by the "not under our control" test, continue to decompose the failure at progressively lower levels. Decomposition stops on a particular path when the contributing factors or causes need no further decomposition—a judgement call, but often pretty obvious. Continue this process until there is a hierarchical "tree" extending under each failure.
7. Specify the relationship between the various contributing factors to the high-level failures. Is just one contributing factor enough to cause a breakdown? Or, are there combinations necessary to do so? The fault-tree hard core like to describe these using AND or OR gates, which are logical operators used to describe computing hardware. In real life, you might need to specify the degree to which a breakdown occurs, the threshold at which a certain factor becomes significant, and all sorts of messy real world conditions.
8. Repeat steps 6. and 7., as necessary, until an adequate fault tree is developed. "Adequacy" is as judged by your SMEs.
9. Analyze the tree. Fault-tree purists label the nodes in the tree (A, B, C..., with contributory nodes labelled AA, AB, etc.). Then, they quantify the nodes, marking a numerical percentage for each failure event to each system-level failure; mark a confidence level in the percentages; quantify the frequency rate for the breakdown; and evaluate the

likelihood of changing or rectifying each of the "bottom" level events. Note that this quantification is a good example of "numerical bias"—the tendency to believe in the power of numbers, even though you know you just made them up. However, this approach may still have utility by simply enforcing a thorough traversal of the fault tree and an analysis of how easy or possible it is to fix common or especially important errors. This last result then contributes to the development of the training plan.

Fault-tree analysis has been presented as though no procedural analysis had been done first. If you do procedural analysis first (recommended), you can save a lot of time by simply stopping at each of the procedural steps and asking, what can go wrong at this point? Then repeat this process, focusing on the links between the steps. The fault tree analysis can proceed, then, from the identified problems for each of the steps and for the "steps" between the steps.

There is a slight risk in this approach of missing "emergent" faults, that is, faults that emerge only when some combination or sequence of events occur. There are plenty of real-world failures that occur not because of some particular fault but simply because of the accumulation of small variations. In some cases, not one of the variations might actually be called a fault, but the combination of a sequence of such variations is enough to throw the whole system or process off. However, if special attention is paid to the fault analysis of the terminal objective(s) of the task, this should be a very slight risk.

PERFORMANCE ANALYSIS

The third, complimentary, task analysis approach is performance analysis. This is akin to fault analysis, but focuses explicitly on the human performance that underlies task performance. In contrast to fault analysis, which may identify deficiencies in system design or resource supply as easily as human error, performance analysis focuses explicitly on how the people do the job. In addition, it is distinguished from fault-tree analysis by its interest not only in actual errors but in levels and standards of performance. Since in many training situations, the interest lies in enabling the performers to do their best, not just to meet a minimum performance "floor", interest in levels of performance is useful. The steps for performance analysis are straightforward.

1. Decide whether there is a performance problem. This can either be with respect to actual errors, or with respect to quality of performance. For example, a toxic containment crew may be required to arrive at the scene of a spill with fifteen minutes. However, the crew boss may decide that for a particular area, the crew should be able to arrive within ten minutes. Arriving in fifteen minutes, then, is not an error, but it may be a performance issue the crew boss wants to address.
2. Determine how you know the problem exists. Especially where there is a chance that there will be a dispute about the appropriate standards of performance, documenting the evidence that indicates a performance problem is critical,
3. Determine which performance element is causing the problem. What is happening, or not happening, to cause the performance issue? At this point, it is important to distinguish the possible from the impossible, and to be certain that the identifications are reasonable with respect to the levels of skill and talent expected of the performance population.
4. Determine where the locus of the problem lies. In the performance of a particular person or subgroup? In the interactions between people or subgroups? Does the

problem only arise in particular situations? Is the problem intermittent? If so, is that because the standard is at the edge of the performers' competence, or because the performers' vary significantly in performance? And so on.

5. Describe the standard of performance for the problematic task. If you have done procedural analysis, you will already have this.
6. In cases where there are multiple outputs from a particular performance step, specify which output is not adequate.
7. Figure out why there is a problem. Jonassen et al suggest three categories of things to consider for probable causes:

- Capability causes, like skills, knowledge, abilities, or physical, emotional, or mental capacities
- Motivational causes, like inadequate incentives or rewards, conflicting goals or expectations, etc.
- Environmental problems, such as inadequate resources or supplies.

8. For probable causes in the first two cases, consider possible solutions. These will likely divide into causes that can be ameliorated by training, and causes that can't. For instance, if there are motivational problems caused by (for instance) unfair rewards, or rewards that are not correlated with task performance (e.g., advancement purely on seniority), no amount of training will change this. Depending on the context, you may or may not be in a position to recommend change in this kind of case.

However that may be, it is important to take the realistic training opportunities away from this analysis. The causes of subpar performance that can be changed by training should be integrated into the picture that has been developed with the previous two task analysis approaches.

BEHAVIORAL TASK ANALYSIS: WRAP-UP

There are many other task analysis approaches: Learning hierarchy analysis, component display theory, mathetics, behavioral analysis, and so on. The three above are suggested as representing a reasonable "spanning" set, that will give (for tasks that can be described adequately by their observable steps) a good description of what the task is, how it is done, how it can go wrong, and what performance elements must be present, at what level of competence, for it to go right. In addition, these three, taken together, will also do the useful job of marking what performance elements are not amenable to training.

COGNITIVE TASKS

Cognitive task analyses are powerful, but the various techniques can also be expensive, and if the training target is at a high level of expertise they can require significant development of domain expertise on part of the analyst. To select the best cost/benefit area within a task, it is common to look at the intersection between the importance of different task areas and task areas that show significant differences in skill between high and low performers.

Most forms of cognitive task analysis have the SME think out loud as he or she performs the task (or the subtasks that have been identified as having the highest payoff). Protocol analysis is uses this approach, along with many other means of tracking what the SME does (Ericsson & Simon 1984). Analysis techniques that focus on elements, attributes, and relationships in the problem domain, and those that use various types of cases - the typical case technique, the tough case, interesting case, prospective case, and retrospective case techniques, and the critical incident technique - try to make covert thought explicit and overt.

We will describe five cognitive task analysis techniques: Cognitive goals analysis, information needs analysis, repertory grid analysis, laddering, and semiotic analysis. Before that, though, we will reveal the Fundamental Law of Cognitive Task Analysis.

THE FUNDAMENTAL LAW OF COGNITIVE TASK ANALYSIS

It takes longer.

Expressed more formally, for any given schedule S, Time (cognitive task analysis) = S + delta n, where n = "more."

GOALS ANALYSIS

Goals analysis begins with the interviewer asking the SME to define the top-level goal for a particular, representative scenario. The goal is then broken down into subgoals and actions that can be executed to move from one goal state to another. The elicitation of subgoals and actions helps the interviewer build both a declarative network representation of the problem elements and a set of production rules representing the goal/subgoal relationship. The session continues until the scenario is completely "unpacked" in terms of its goals and actions.

Multiple goal analyses sessions are held, each with a different scenario, until a good spanning set of representative scenarios have been covered, that is, until enough of the task has been covered that the training need will be able to be addressed.

In the best of all possible worlds, multiple SMEs will participate in independent goal analysis sessions. This minimizes the risk of a false reading from encountering a SME with an idiosyncratic approach to the task.

At that point, the training designer does three things:

1. Distinguish cognitive from behavioral goals. This can be a highly productive activity for identification of gaps in the data gathering. By cross-correlating the behavioral and cognitive goals, gaps in the latter can be identified. Goal analysis assumes purposeful behavior. Therefore, every behavioral step should be motivated by a corresponding cognitive goal, and if breaks in correspondence are found, the cognitive goal elicitation can be rejoined to repair the gap.
2. Analyze cognitive goal tree overlap (common subgoal trees).This highlights the recurring cognitive structures within the domain.
3. Analyze the underlying reasoning strategies. For example, how tenaciously are particular kinds of subgoals pursued? Is there anything other than goal satisfaction that causes a

switch from one subgoal tree to another? And how does the expert tell when he or she has reached that point? How are assessment, diagnosis, planning, and action mixed? How does one know when a goal has been satisfied? What kinds of subgoals tend to be pursued in parallel? How are cognitive goals distributed across behavioral steps?

The time cost of goal analysis rises with the complexity of a task; the more complex, the more time required to decompose it into its constituent goal/subgoal structure. Goals analysis typically generates a rich dataset which must be assessed and, in some cases, reduced. Goal analysis assumes that an expert's knowledge can be characterized as a propositional network of factual information operated on by a set of procedures. If the task domain is such that this assumption is not viable, then goals analysis should not be used to elicit knowledge.

INFORMATION NEEDS ANALYSIS

Information needs analysis approaches a cognitive task by cataloging the information used during task performance. In outline, information needs analysis is straightforward. Simply track each step in the process and determine what information flows into and out of the step. Then analyze the information to inductively build a model of the cognitive task.

As will come as no surprise, in real life it is not often this easy. The chief issue is that since the problem is to infer the structure of the cognitive task, you don't often get to start with a clear notion of the sequence of cognitive steps - you'd be starting with a good chunk of the thing you're trying to infer.

For this reason, information needs analysis is a nice compliment to goals analysis. The goal-tree can be used to structure the information needs analysis, with queries centering on each of the goals and subgoals.

Some points to incorporate in an information needs analysis:

- The obvious thing to ask the SME is what information is necessary coming into a subgoal, and what information is produced during the process of satisfying the subgoal. Both the information content and its form need to be recorded. Recalling the discussion of distributed representation, the form of the representation is significant.
- The less-obvious thing to ask is why the information is necessary or useful. This can help uncover further information, and it can also reveal subgoals that had not yet been articulated.
- This process is recursive - it is important to understand what information (and knowledge) the SME-stated information depends on for its utility. Usually information is useful to the extent that it allows us to make distinctions and to discriminate between possible choices or courses of action. But such distinctions usually depend upon prior supporting information and knowledge, sometimes a great deal of it. The value of pursuing this is that the elements of

this information and knowledge that are task-specific are also likely to be those that need to be trained.

- You can't necessarily trust your SME. Not through evil intent; SMEs often go out of their way to be helpful. The problem is a form of "repetition blindness." If an SME performs a task for long enough, some information issues will become so "natural" in the SME's eyes that they will fade from conscious view. The SME may be using information from the environment without being conscious of it. One advantage of recursively following information patterns is that these unconscious perceptions can be discovered and articulated.
- Don't forget the triggers. In many cognitive tasks, the first (and sometimes most important) step is to notice or determine that there is a need to perform the task. It is easy in information needs analysis to neglect elicitation of the information required to initiate the task.

REPERTORY GRIDS & LADDERING

The repertory grid technique (Kelly 1955; Boose 1984; summary in Boose 1990) uses a two-step approach to eliciting the underlying organization of knowledge of a domain.

First, SMEs are presented with triads of elements from the domain, and asked to group two of them in contrast to the third. These similarity judgements group and differentiate elements of the domain. Various combinations are presented to the SME until he or she believes that a spanning set has been considered. Because similarities often result from similar values on an attribute and thus can be used to identify the attributes, the product of this activity is a set of dimensions that subjects use to organize and understand the stimulus set. The second part of the first step is the naming of the dimensions and the rating of the domain elements with respect to the dimensions (thus the grid - dimensions by cases). That is, once the SME has established that A and B are more similar to one another than they are to C along dimension X, then elements D, E, and F are also ranked on dimension X. The ratings are submitted to correlational analysis to determine the relationship between dimensions.

The second half of the repertory grid method uses simple ratings to assign values to the attributes (dimensions) obtained in the first half of the method. These ratings illuminate the structure of the dimension, such as binary (yes/no), continuous, discrete, directional, and so on.

Laddering is a third, somewhat independent step that augments repertory grids. Using selected individual elements and hierarchical discrimination questions, different abstraction levels within the SME's mental model can be identified. In English, this means you ask the SME questions like, "A is an example of what?" or "Which of these elements is an example of A?" By pursuing this kind of inquiry, you can get a good notion of the different levels of the domain.

If the cognitive task involves a significant amount of classification (most diagnostic tasks do), repertory grids and laddering are effective and (comparatively) inexpensive techniques.

SEMIOTIC ANALYSIS

Semiotics have a funny reputation in science, probably because the methods originated in the study of literature. Just because some French intellectuals invented them doesn't mean the techniques aren't useful, though. To illustrate semiotic analysis, we'll use a framework proposed by Lemieux and Bordage (1992). Similarly to the declarative/procedural distinction in psychology, semioticists distinguish knowledge and the operations that can be performed upon it.

Lemieux and Bordage propose three levels of knowledge:

1. Constituent units are the various pieces of the domain. For example, in medicine, symptoms, tests, conditions, and states would be constituent units.
2. Morphological units form the grammar of the domain, that is, how things fit together and what they mean.
3. Mental operations are the productive combinations of constituent and morphological units to achieve domain goals.

Lemieux and Bordage name five categories of mental operations that together comprise competence:

1. Definitional operations are concerned with the form and substance of the domain content.
2. Classificatory operations locate the content within a taxonomy (used in the general sense of a system of organization).
3. Hierarchical operations are concerned not with level in a taxonomy, but with relative importance. The hierarchy is a salience hierarchy, which is assumed to be content-sensitive and dynamic.
4. Associative operations are the process of putting material in context, e.g., similarity, analogy, difference, equivalence, compatibility, and so on.
5. Generative operations are about causal relations and inference.

A semiotic analysis proceeds in five stages:

1. Collect protocols. This is the basic data gathering. It can proceed by presentation of various cases in an interview setting (as mentioned above) or by field observation.
2. Code the transcripts according to knowledge level.
3. Analyze the coded transcripts by mental operation.
4. Extract the patterns of sequence and dependency.
5. Complete the characterization of the domain.

Five easy-to-name steps. Unfortunately, like other approaches involving close analyses of protocols, it can be extremely labor-intensive. The benefit is that a very thorough analysis can be performed, and the product of the analysis is in a form that is easier than most to translate into training goals.

TEAM TRAINING

What emergent, trainable characteristics distinguish teams from the actions of their members? Team training often focuses predominantly on development of individual skills in a team setting, in effect having the constituent individuals each practice their contributory skills. Even something as intrinsically team-oriented as compensatory behavior can be seen as an individual skill. But what about team skills which are not necessarily individual skills exercised in a team setting? Do such skills exist? How could they be trained?

It is known that for many NP-hard problems (where the number of possible solutions is exponential and the minimal solution path requires traversing all possible points in the solution space), excellent but non-optimal solutions can be found by techniques that trade local optimality for global goodness. To see why this works, consider design of a complex artifact, a jet airliner for example. The optimal solution for the design of the hydraulics and the optimal design for the passenger compartment can easily conflict. Even more basically, the need for airframe strength is likely to conflict with the need for airframe lightness. Because problems like these typically involve mutual exclusion of possible substates, optimal solutions are simply too difficult. Compromises are necessary to find good solutions. As an old engineering heuristic has it, "the best is the enemy of the good."

The implication for team training is that a key element in successful teams is individuals' sublimation of their own best performance in the pursuit of the team's best performance. A team's best performance may result when the individuals who make it up do not each provide their individual best performance.

This is not obvious to everyone. It distinguishes higher-performing teams from lesser ones, and it is certainly trainable. It appears to be an emergent property, a team, not an individual, skill: It must be coevolved among the individual team

members. The notion of coevolution of skill, then, is a candidate marker for emergent team skills that are not summary individual skills. There is a lot of work in both ecology and in complexity theory that supports this idea. But it is speculative at this point, based on field observation but not yet on controlled experimentation.

In the following, we'll cover task analysis for teams, both behavioral and cognitive. Some of the material covered in the sections on individual tasks can also be applied to teams - the fault tree analysis in particular, with its emphasis on the system level, can easily be applied to teams. Team behavioral task analysis first.

TEAM BEHAVIORAL TASKS

The first step in team behavioral task analysis is to perform a procedural analysis with the unit of analysis being the team instead of the individual. As with individuals, the three preconditions for team procedural analysis are that the task comprises behavioral steps that form a consistent sequence; the sequence, once recorded, can be followed; and following the sequence always results in task completion. ("Always" being as absolute or as probabilistic as is appropriate for the task domain.)

The five procedural analysis steps:

1. Record the team's terminal and important intermediate objective(s), and the standards of performance for each. Care should be taken that the objectives of the team leader or key team members are not mistaken for the overall team goals. It is also useful to record the functional role of each intermediate or enabling objective. This can be used to distinguish steps whose temporal order reflects an underlying dependency relationship and those whose ordering is for convenience or out of habit.
2. Find a competent team that can be observed performing the task in a real-world environment. This is much more difficult for teams than it is for individuals, especially for tasks that are performed in a highly dynamic environment. Military, police, fire, and paramedic teams may need to respond to a wide range of circumstances, making observation of specific tasks difficult.
3. Observe the team performing the task and record the task steps. Depending on the variability of the task and the dynamism of the environment, this step may need to be repeated a number of times. In a highly variable environment, observation of multiple teams may also be useful.
4. Convert the recorded procedure into a step-by-step procedure description. It is again incumbent on the analyst to maintain a clear distinction between the team and the individuals who make it up.

5. Test and validate the procedural description. Once again, this is harder for teams than it is for individuals, and it is harder for tasks performed in dynamic environments.

The result of these steps will be a procedural description of the team's task. It will include information on task steps that can be performed in parallel and steps that cannot.

The second analytic step is to integrate the team model with the various individual task performance models. This is a somewhat painstaking process of knitting together and teasing apart.

1. Match and connect the team procedure with the individual component procedures. This is the knitting together. Note that individual tasks will often cross over the boundaries between team task steps.
2. Analyze the integration with respect to the eight elements of teamwork. For example, every team step has some initiation conditions, some reasons why it is time to begin performing it. To the extent that these are contingent upon the performance of multiple individual tasks, then the teamwork elements necessary to coordinate those individual tasks and signal to the team that the team task step can be begun should be analyzed. That is analysis of team step initiation; the same kind of analysis should also be applied to within-step individual-to-team coordination activities. The more deeply the task penetrates into the realm of real teamwork (as contrasted with side-by-side taskwork), the more complex and difficult this analysis will be, but the more necessary as well.

This two-stage procedural analysis can be augmented by a performance analysis that focuses on the eight team interaction behaviors. The subject of this analysis would be the interactions between team members. This analysis must do two things. It must examine particular teams and the interactions within them, and it must then generalize this for the subject *category* of teams. That is, to be useful for training, the idiosyncrasies of a particular team need to be discarded, but

then general problems that any team will encounter need to be preserved and highlighted.

These analyses will effectively span the team behavior space.

TEAM COGNITIVE TASKS

Cognitive task analysis for groups is a new field. Unlike task analysis, it hasn't had fifty years of development, and its methods are more controversial than those of its behavioral counterpart.

Not that behavioral task analysis has a lot of solid comparative studies. Reading the task analysis literature, one encounters a lot of material that is presented on the basis of "we thought this was a good idea and we tried it and it seemed to work." Note that the authors don't actually *say* that. They usually say they found some failure or fault in the other methods and invented a new, improved approach. There are many improved approaches; it is almost (but not quite) as difficult to find an approach that isn't "new and improved" as it to find a controlled, comparative study.

With that preamble, plus the probably unnecessary reminder that cognition is harder to study than behavior, we present four team cognitive task analysis approaches: Team cognitive goals analysis, team information needs analysis, distributed representation analysis, and team metacognition analysis.

We hope that over the coming years, the needs of and for team cognitive task analysis will see a meeting and blending of methods from psychology, sociology, and anthropology in order that we might have much better methods than can be presented below.

TEAM COGNITIVE GOALS ANALYSIS

Teams have goals that individuals share as members of a team but cannot hold as individuals. This is often obscured because members of good teams, and especially team leaders, so strongly identify with the overall team goal(s). (Is this the source of the odd grammatical convention of kings and corporate bosses referring to themselves in the plural?) Nevertheless it is true. No individual puts out a canyon fire or wins a soccer game.

The analytic implication is that team cognitive goals analysis proceeds on the same lines as individual cognitive goals analysis. The team as a whole is treated (in a limited sense) as though it were an individual. Top-level goals are defined for the scenario, then unpacked into subgoals, with the unpacking process continuing until the team goals bottom out by intersecting the individual goals. Goal analyses sessions should be held with different scenarios and with SMEs representing each of the roles or positions used in the team.

The cognitive goals should be clearly distinguished from the behavioral goals. In some cases this will be obvious on the surface, in others it will need to be teased out - why is a particular team behavioral goal adopted at a particular point in the task process? How tenaciously are particular kinds of behavioral subgoals pursued, and what cognitive goals motivate what levels of behavioral activity? How are team cognitive goals distributed across team behavioral steps? And so on.

- Self-reports are frequently inadequate. Task observation is necessary. Effective teams may practice sophisticated information sharing without being consciously aware of doing so. In particular, information "publication" is of interest. By this we mean the performance of some portion of the task in a way that makes performance or markers of progress more visible than is strictly required by the structure of the task.

DISTRIBUTED REPRESENTATION ANALYSIS

Distributed representation analysis is applicable to team cognitive task analysis because for some team activities the whole of a thought or plan is distributed over the whole system, with the various participants each only having/being part of it, and perhaps none compassing it in its entirety.

There are two steps in distributed representation analysis. The first is simply to determine what the shared representations are. Some of this will be totally straightforward. If the doctor writes an observation on a chart and another doctor subsequently reads it, this is pretty easy to observe. Less easy to detect are the unconscious or "incidental" representations. Hutchins gives the example of the characteristic placement of a pencil stub at a particular angle in between two gauges in the cockpit of a 747. The placement of the stub records a reading taken at a particular time and additionally signals that the overall joint process is proceeding on schedule. As an observational task, detecting a pencil stub placement as a significant distributed representation action is difficult, requiring as a minimum both an alert eye and a large amount of detailed domain knowledge.

The second, and despite the example, generally more difficult part of distributed representation analysis is figuring out what each instance means for the team cognitive task with respect to trainable skills and capabilities. This is the painstaking process of working out the function(s), required supporting assumptions and knowledge, and implications for each of the instances.

To the extent that the analysis is with respect to function, this analysis is closely tied to the team cognitive goals analysis.

METACOGNITIVE GOALS ANALYSIS

Metacognitive skills monitor and control cognitive activities in such a way as to maximize their effectiveness. A wide range of mental operations fall into this category: Managing focus and duration of attention, detecting problems, monitoring progress and assessing when a change in approach is appropriate, and so on. Metacognitive skills can be thought of as self-management with respect to problem-solving.

Salas *et al* (from whom the seven of the eight teamwork characteristics were taken) discuss three broad aspects of teamwork. Two, taskwork and teamwork, have been covered in detail. The third they call "jelling," by which they mean the degree to which a particular team manages to fit together and make itself more than the sum of its parts. A significant part of the jelling process has to do with effective team-level metacognition.

Sternberg identifies four metacognitive skills:

1. Identifying and defining the problem, including recognizing that there is a problem to solve.
2. Representing the problem, including how to figure out exactly what the problem is and how it should be framed.
3. Planning how to proceed.
4. Evaluating performance as it occurs and continually performing the preceding three steps during performance.

The approach to team-level metacognitive analysis is to examine the team as a whole for markers of metacognitive activity. When and under what circumstances do each of the four metacognitive activities occur? In what way do they change and improve team performance?

In order to do this, comparative study of long-term and newer teams is desirable. In some fields this can be difficult, for any number of reasons: There are no long-term teams, long-term teams are always composed of more individually experienced members, or long-term working relationships exist but team

boundaries shift and reform enough that specific on-the-team/not-on-the-team assignments are difficult to make. If, though, such comparative studies can be made differences in performance between otherwise matched teams can provide useful material for analysis.

TEAM COGNITIVE TASK ANALYSIS WRAPUP

Cognitive team task analysis is a new activity. The approaches described above could easily be criticized as having excessive redundancy and often-vague completion criteria. On the one hand, such criticisms would be valid. On the other, a reasonable picture of the team cognitive task can be developed using the methods described.

It is useful to remember that the point of all this work is to be able to design and implement more productive training. Even though the epistemological elements of cognitive modeling must be elucidated for long-term progress to be made, it is not the obligation of the training designer to do so. At every point in the team cognitive task analysis process, it is fair to ask, "what difference does this make?" If a reasonably persuasive answer cannot be given, there will be little point in pursuing the particular line of investigation.

RELATION TO INSTRUCTIONAL GOALS

Having made it this far (congratulations! And thank you!), you have the tools with which to define the features and processes of your target training task, both behavioral and cognitive, for both individuals and teams.

If you have performed some of the analyses, especially any of the cognitive analyses, you are probably in state of something like astonishment that people are able to manage the incredible complexity that underlies even the (apparently) simplest tasks.

The next step is training design. There are four routes you might take from here:
1. There are some basic elements of training shared by all effective training programs. These are introduced in <How To Use The Guidebook>.
2. Our expert-system-based training advisor will recommend training techniques according to how you answer "a few" (198) questions. These questions let the system build an abstract characterization of the task you wish to train - does it take place in a dangerous environment? Does it require extended vigilance? Is mutual monitoring of teammates a critical element? And so on. The system will then make recommendations based on our survey of the current state of the art and on our own research. Go <Training Advisor>.
3. Look at our research on teamwork. See what we asked our subjects and why, how we analyzed the resulting data, and what we found out. Go <Teamwork Research Findings>.
4. Go directly to the Guidebook, where you'll find descriptions of myriad training approaches. Go <The Guidebook>.

UNIVERSAL ISSUES IN TRAINING

There are some issues that any training approach will have to address:

- Deciding who to train
- Prerequisite skills and knowledge
- Expectations
- Establishing an environment for training
- Motivation
- Goals
- Feedback
- Reinforcement
- Transfer

None of these are problems with definitive solutions, just issues to recognize and integrate into training.

DECIDING WHO TO TRAIN

Training is clearly essential but must be used selectively to meet the needs of the organization as well the individual. Some suggestions are included here to help managers to decide who should receive training.

It is important to be aware of the reasons behind the training. Is it job training, training for advancement, or new practice or technology training? If the purpose of training is based on set aims for the organization, this will make trainee selection easier.

Training newcomers is often the easiest need to identify. Be careful, though, to assess individual needs especially when post transfers are involved. Orientation may suffice.

Job training can be initiated when a need is identified by those performing the job. It is important in this case to ensure the resulting training is offered to those in the areas indicated by them.

New technology or major changes of any kind should always be geared to key areas and so to the people directly involved. It's been noted that training everyone creates resentment in those who are not permitted to use their new skills. It also undermines respect for management.

It's worth bearing in mind that people often associate training with job advancement. This is another reason to clearly explain the motivation for training and whether or not it does entail a job advancement. Advancement can be related to training itself, for example in the delegation of further training responsibilities to the person you select first.

Be sure to discuss clearly the aims and expectations of training with key subordinates. This will help determine who needs it. Needs assesment, making training seem important, and choices about training are related topics which should help in this kind of decision making.

PREREQUISITE SKILLS AND KNOWLEDGE

To train effectively, knowing the abilities of the learners as they enter training is necessary. It both saves time and communicates respect. Inadequate assessment and training pitched at the wrong level can if too easy lead to boredom and if too difficult to breakdown of the learner's sense of personal control ("I can't learn this") and thence motivation ("so why should I try?").

Assessment is the evaluation of a person's strengths and weaknesses on a certain set of tasks, in order to determine what things they need to work on (either on their own or through training). What is presented below is not how to select tasks to be assessed, nor is it how to assess them, nor how to design training based on the needs - it is how to present needs assessment. Selection of areas for assessment and design of assessment instruments are domain specific. How to design training is covered later. The following is about how to present assessment results.

Because we don't like to hear what is wrong with us, we tend to want to discredit the source or in some other way make it so that we don't have to believe what the assessor is saying. It is important to present training or learning needs in such a way that

1. The learners don't feel the urge to do this.
2. They don't have a basis for doing it.

If you do this poorly, they may revolt against the training or dismiss the information.

In Noe's list of necessary conditions for learning, the first entry is the belief that assessment of personal strengths and weaknesses is accurate. There are four things you can do.

- Tell the trainees why the assessment is being done. Be honest.
- Involve trainees in the needs assessment. Have them help figure out what needs to be trained and how best to train. This input must be used, though - it backfires seriously if you ask for their opinions only to ignore them.
- Tell people how the needs assessment was completed. This will reduce suspicion, fear, animosity towards the training.
- Make sure that the information is accurate (credible) and that it comes from a trustworthy source. If the employees or trainees

have some a priori reason to believe that you aren't trustworthy - there are plenty of Dilbertian reasons this could be the case - then this needs special care.

If employees do not understand why and how their needs were diagnosed, or feel that the information (or its source) is not credible, they will be resistant to change - both in resisting the training and in not making use of the information provided about their comparative strengths and weaknesses.

It is important to frame the results of the assessment in a constructive way. Avoid making it competitive - finding that you are labeled with a particular "weakness" whereas some other person isn't could lead to feelings of insecurity or resentment both towards them and the suggestion. On that note, make sure that being placed in training does not become a signal reduced status ("you are a loser").

But at the same time, don't hold back information that could be useful because you don't want to hurt someone's feelings. The optimal situation is where you can make it clear to them why you are telling them - so they can get better!

This brings up a complex point. In the huge majority of domains, we assume good will, a desire to improve, and mutual respect. There is a traditional exception: Military boot camp. This is a special case, in which the intent of assessment information may be to break the trainee down, so that he or she can be psychologically remolded into someone who will unhesitatingly kill or die because he or she is told to.

The more often needs are assessed, the less critical it is to be careful about the way one does it in any one instance, as people will grow accustomed to it. On the other hand, the more important it becomes in general, because the cumulative effect of how you do it is greater, and you may end up making people ignore you all the time.

If trainees perceive that their training needs have been accurately diagnosed and that it provides useful information about strengths

and weaknesses, they will react favorably to the assessment.

EXPECTATIONS

Expectations have a huge effect on both training outcomes and on trainees' subjective assessment of training. Giving trainees accurate expectations of what is going to happen during training, and what the results are going to be, is a very good idea.

Hicks and Klimoski (1987) sent out either meaningful or bland descriptions of the training that the people were about to engage in. They found that having realistic expectations caused

- Greater motivation to learn.
- Greater commitment to attend.
- Greater feeling that the training was worthwhile.
- Stronger sense of being able to profit from the training.

Tannenbaum, Mathieu, Salas, and Cannon-Bowers found that expectation fulfilment was related to commitment, self-efficacy (both physical and academic), and motivation (although the effect was smaller for self-efficacy). They also found that liking the training led to commitment and physical self-efficacy.

Noe found that trainees who had their pretraining expectations met (e.g., degree of challenge, opportunity to practice) developed greater postraining commitment, self efficacy and motivation.

So - having appropriate expectations and having them fulfilled is good. Be sure that trainees come into the training with accurate expectations, by telling them what to expect (and if appropriate what not to expect), and then, meet their expectations.

Baldwin & Magjuka (1991) found that if you enter training expecting a follow-up activity or assessment, you will report stronger intentions to transfer training back to their jobs.

Noe claims that labeling training as an "opportunity" produces better outcomes, by generating higher learining expectations. However, care needs to be exercised. Labeling effects are real, but if, for example, downsizing has produced a situation where one person is being trained to do the work that two people used to do, telling him or her that it is an opportunity will merely rub salt into the

wounds.

It is important to make sure that the necessary conditions for using the new skill (equipment, information, environment, etc.) are present *before* beginning training. Immediate application improves retention, and conversely, a clear lack of application reduces motivation - why do the work of learning if you won't be using the new skill?

There may be situations where you don't want trainees to have full knowledge of what is going to happen next. It may be that they need training in dealing with surprise, or too much prior knowledge will cause heightened anxiety if an unusually stressful situation is anticipated. (See the Guidebook sections on stress training for more discussion.)

If trainees know what to expect out of training, they will feel more self-assured (in contrast to feeling unprepared or helpless). As expectations are met, they will feel they are making progress. And, they will not be shocked, scared, or anxiety-stricken as new tasks, goals, or techniques are introduced. If they know why they are being trained and what benefit they can reasonably expect, they will be more willing to accept the training as worthwhile and commit to doing well.

ENCOURAGE GOOD HABITS

Good training habits are worthwhile instilling in the trainee to the point where they become automatic. It helps if trainees also have this as a conscious aim. Be clear that you always expect behaviour appropriate for training and use techniques that encourage this such as contracts and establishing a training environment. This helps to create the right notion of what training is supposed to be like.

When you use a training technique, it may help the learner if you explain what you are doing. In this way he is encouraged to think and act in a similar vein. Lead by example, always taking the attitude you want trainees to take. Ultimately, a trainee's attitude and actions should be maintained without any external example.

If there is more than one trainee, a new trainee will take cues from the others.This is also true vice versa. If you have already established an environment where the learners concentrate and work hard with a positive attitude, then a new trainee will usually fit right in. However, a new trainee may sometimes change the environment negatively, instead of adapting to it. In this case, basic training techniques, including socialization, are called for once again.

Reward good training accomplishments, but distinguish between improvement and performance. Trainees should be aware that their efforts can be rewarded while their performance standard is not yet satisfactory. Rewarding improvement fosters concentration as well as good attitudes. Shaping is a particularly worthwhile technique for this purpose. The emphasis is on positive reinforcement as a more productive approach than punishment for lack of concentration.

As self mastery increases the need for reward declines. Be careful not to withdraw rewards too early. Monitor mood as well as achievements to avoid this, because rewarding progress can also aid in making training more fun for the trainee.
Concentration can be instilled as a habit. Make sure that when practicing, the student is concentrating. Do not practice when they are not concentrating - if they stop, you stop and make them start again. This may be difficult, but the aim is to always build in periods

of consistently high concentration during training. Formal breaks or short times of less intense activity should be clearly signalled. Be sure to make them very distinct from the times of high concentration.

Confidence is an important factor. It can be encouraged by ensuring that trainees feel good at the end of every training session. Make an effort to see that the start of training sessions is enjoyable. This helps trainees come into practice feeling comfortable and self-assured. Outright intimidation or premature challenges may have a damaging impact on confidence and self-efficacy, even if the trainee meets the challenge. (Techniques like enactive mastery are applicable here.)

Although much training may not be intrinsically enjoyable, an effort to add an element of fun may prove very worthwhile. A positive mood is thought to be fundamental to good training habits. This does not mean constant laughing and smiling. It does involve a confident outlook on both life and training and can be caused by the feeling that one is doing well. For this reason, reinforcement and acknowledgment of progress are important. Train with a view to establishing a positive general outlook, and desirable training habits and good results should follow with ease.

MOTIVATION

People who want to learn, learn if there is even the slightest chance of doing so. People who don't want to learn, generally don't. Motivation, therefore, is crucial.

Motivation varies in both intensity and the duration and reliability with which it can be expected. A lot ot jobs have typical motivation curves - inverted bell curves, most commonly, or in some cases just the descending part of inverted bell curves! Being realistic about learner motivation is a prerequisite to using it as a guide to training design and method selection.

A high level of motivation has to be present to achieve excellence in tasks calling for significant expertise. The learner needs to be able to attend consistently to the most difficult parts of the task, that is, to spend most of his or her practice time doing what he or she is worst at. Abundant and reliable (mood-independent) motivation is necessary, since the focus is consistently on the least obviously rewarding parts of the task.

Most tasks, however, do not require that level of motivation. There are a few simple things that can be done to make the most of the available motivation:

- Respect it and and don't violate it. Training should both be and (a different thing) show itself to be fastest, straightest way to achieve the trainee's goals.
- Reinforce and/or reward progress fairly. If motivation is viewed as a kind of exertion, then being sure that training includes events with unambiguous beginnings, middles, and ends - it's much easier to exert when you can see the finish - may make maintaining a sense of progress easier.
- Affirm and reinforce belief in personal control, e.g., that the learner can learn and master the material.
- Don't over-challenge early. This can lead to discouragement and a reduction in belief in self-efficacy.
- Don't under-challenge late. This can bracket training at a lower-than-necessary level.

Baldwin et al (1991) found that if you give trainees a choice about

what and how they want to be trained, it raises motivation. However, soliciting this information and then ignoring it is a violation of trust, and is measurably worse than not soliciting it at all.

A sense of improvement and a belief that the learned material is useful or beneficial is fuel to motivation. A sense of statis, impossibility, or uselessness is poison. Therefore, be realistic about trainee motivation coming in, nourish it, and avoid squashing it. It's the astute trainer's greatest ally.

GOALS

Goals are generally helpful in training. However, there are different types of goals. In this section, we distinguish learning and performance goals.

It is typical in training to state a goal as "be able to perform task X, within time Y, to degree Z" - measures of performance (MOPs). These are performance goals. They are about how fast and how well the trainee can do the job.

The trainee's job is to learn to do the task, and it is typical for trainees to interpret their job to themselves as a matter of doing, rather than of learning. It is possible for trainees to have, instead, learning as their explicit, conscious goal. Some research suggests that trainees who approach training with the attitude that they want to improve, much more importantly than doing well in the short run, achieve higher levels of performance.

To begin, we will contrast the effects of performance and learning goals. This is a biased comparison—you'll see more of the desirable effects of learning goals than of performance goals. With that in mind, and remembering that setting learning and performance goals is NOT an either/or proposition...

Trainees seek to maintain positive judgements and avoid negative judgements by others, by seeking to show or document their ability to satisfy the training goal - or by seeking to avoid discrediting it. To do this, they focus on their current ability.

They are concerned with measurement of the ability (MOPs), asking, "Is my ability adequate?" When they practice, they do it to find out how good they are, to test themselves against perceived expectations, and to judge themselves by how they measure up. If they don't (which they probably won't, since otherwise they wouldn't need training), they can experience fear of failure, helplessness in the face of failure, negative affect (sometimes), and impaired performance (things go from bad to worse). On the other hand, if they meet with early success they may become complacent or overconfident.

The problematic aspects of performance goals, then, are:

- Belief in low ability may lead to loss of belief in utility of effort.
- Withdraw of effort to forestall continued documentation of failure.
- Worry, which can divert attention from the task to be learned.
- Shame and anxiety, which motivate escape attempts.
- Trainees can self-handicap, adjusting their level of effort to maintain an "I wasn't *really* trying" margin.

Any or all of these can lead to blockage of the trainee's crucial intrinsic rewards for improvement.

Learning goals

If, however, trainees see their goal as learning, they will focus on increasing their abilities and mastering new tasks. This leads to strategy formation, positive affect, and sustained performance.

Instead of asking, "Am I adequate?", they are asking "How can I best acquire/improve this skill?" Failure becomes valuable, analysis of failure a crucial source of information—"If knowledge is power, failure is fuel." Failure and setbacks lead to desire for more practice, adjustments of strategy, and hypothesis formulation and testing. The inevitable errors are not perceived as failures to meet goals if the trainees are focused on learning goals.

Learning goals can't be set without performance goals—to set sensible learning goals, you have to know what you're trying to do, and how well you need to do it. Learning-as-goal tends more toward attitude, as performance goals tend more toward the concrete.

To facilitate good use of both, the trainer can set up a distinction between practice and performance. Not that trainees should practice mistakes, but that the training space is safe for mistakes. Trainees are not punished for mistakes, nor are training sessions necessarily used as tests of performance. Then, during practice, the trainees are focused on trying to get better, rather than to perform at a particular level or becoming over-concerned with avoiding errors.

By establishing the mindset that learning is the most important thing, trainees will do a lot more learning. This will lead to trainees who are less inclined to give up, who enjoy training more, and who will choose to practice to learn, instead of just practicing to perform. It will also lead to training graduates who continue to improve on the job.

That's not all there is to it, of course. Just as with performance goals, learning goals need to be set at the right level. If trainees set themselves unrealistic learning goals, they can become discouraged not only about performance but about their ability to even learn. If the goals are too low, again the problem of complacency and plateau may arise.

There's one more thing. The trainer can suggest learning as a goal, but if he or she suggests particular learning goals, these transform themselves into performance goals. The key element is the locus of evaluation. For performance goals, it is external. For learning goals, it is internal.

Learning goals are most useful when you are trying to avoid the ill-effects of errors, under the constraint that the training space can be made safe enough for errors. There are many variations on "safe enough" in this context. It may be that errors are easily found and corrected (learning computer programming), or that the subject matter can be altered (medical students practicing surgery on cadavers). The word "enough" is included to indicate the trainers responsibility to judge both safety, and to the degree the task must be altered ("no live ammo"), by how much it can be altered and still retain its essential character.

Learning goals are relatively more important the more the trainee's ability is put on display during practice.

For simple tasks, or for trainees who believe they are doing great all the time, performance goals alone may be adequate.

If a task is simple enough, or draws strongly enough on existing skills, e.g., just reconfiguring them for a new duty, or if the level of performance required is mild enough, learning goals may not be necessary.

If the task is found by the trainees to be intrinsically interesting - training kids to play video games, for instance - they will spontaneously set their own learning goals, and trainer intervention may be superfluous. It might even be perceived to condescending.

If the learning is never fun, or the emphasis on learning makes goal achievement less satisfying (because of a compulsion to move to the next thing), motivation will decline, or the task will come to be seen as impossible. Trying to improve all the time doesn't really leave a lot of room for messing around and having fun, which in some domains - science and engineering, music, athletics - is an important component of long-term learning.

In sum, it is rarely wrong to set learning as a conscious goal.

FEEDBACK

Feedback is a recurrent theme in training, but there are quite a few things covered under that umbrella. Information, reinforcement, and reward and punishment are all called by that name. But they're different things. We'll briefly try to pull them apart, then we'll discuss feedback in a little more detail..

Feedback communicates specific knowledge, typically about the difference between current and desired performance. If it comes from a trainer, it is normally given to improve understanding. *Reinforcement* generally communicates encouragement (or discouragement), and is given for motivation. *Reward and punishment* are also given for motivation. "Keep your elbow high, it's a little low..." (information) "...but that was still good!" (reinforcement) "... and if you keep it up, I'll take you out after practice" (promise of reward).

Because attention is almost invariably a form of reinforcement, and because feedback is invariably a kind of attention, feedback and reinforcement are tightly intertwined. However, they have different goals and different roles in training.

Feedback comes in two forms, self-directed observation and external guidance. For each of the two kinds of feedback, there are two forms. Action feedback occurs during task performance. It is most effective when it comes in direct conjunction with the action that is the target of the feedback. Learning feedback occurs after completion of task performance.

If self-directed observation is difficult or subtle for a particular task, there are two options for training. First, the environment in which the task is performed can be simplified to make the relevant cues easier to recognize. Second, the trainer can point out the relevant cues as they are encountered (external guidance), gradually reducing the feedback as the trainees become accustomed to noticing and correctly interpreting the cues. These approaches can be used either separately or in combination.

Action feedback is a good choice when (a) a single element of the

task is the subject, (b) the trainees are able to absorb and use the feedback while performing the task, and (c) there is a clear path to not needing the feedback.

Learning feedback is appropriate when the subject is interactions of actions taken at different times during task performance, when the topic of the feedback is generalizes over multiple actions, or when task performance is so demanding that trainees cannot really absorb the feedback while they are practicing.

Holding claims that action feedback leads to better performance in the short run but worse long-term learning. The gist of his claim seems to be that if trainees use action feedback "automatically," that is, just do what they're told when they're told to, they don't integrate and truly learn as they should. Learning feedback can't be used in this "just follow instructions" way, so the process of making sense of the feedback and thinking about task performance leads to better, more durable learning.

The key issue is the degree to which the trainee is able during practice to attend to his or her intrinsic cues as they connect with the perceived state of the task and the environment. If action feedback is internalized and not just followed, then its immediacy can strengthen these intrinsic cues and speed learning. But if the task is too fast-moving or complex, such attention may not be possible and learning feedback will be better.

For some tasks, the two can be approximately combined by using films or video, so that the specificity of action feedback can be sustained, but the attention of the trainee can be fully on learning (see the Guidebook section on Behavioral Modeling).

Over time, less and less action feedback should be necessary. As this occurs, learning feedback can shift from lower, more detail-oriented feedback ("always try to keep your elbow up on your forehand") to more general, "strategic" observations ("don't let him approach the net").

What kinds of content should feedback carry? Essentially, "what", "how", and "why".

What includes observations of various specific aspects of trainees' performance, what might be changed, what they have done, the results of their actions, how the results might have been different, what they might do instead, and what results they can expect. This can also include providing more cues for the trainee - timing them, recording them, comparing them to standards, and so on. This may include making the cues stronger early in the training, especially if the cues are very hard to notice unless amplified. The trainer's role here is to increase the amount of information available to the trainees.

How includes helping the trainee recognize and understand the cues provided naturally by the environment. If there are non-obvious cues that have a particular significance these should be pointed out. Explain the relationship between the environmental cues and the trainees' actions, with emphasis on cues that depend on and change according to the trainees' actions. Sometimes it is good for the trainer to delay or even withhold feedback. It can push the trainees toward learning to look for and use direct feedback from the source (see Feedback - Delays and Pauses and Feedback - Withhold)

Why includes instruction on the goals of the activity and how these fit into a longer-term vision. This is useful especially when there are many ways to achieve the larger goals and the trainees will need to think independently. It will also reduce reliance on the trainer. This in turn increases the trainees' ability to improve, since the trainee starts to become his or her own trainer (see Advance and Back Off).

Common problems in providing feedback are pretty predictable: The wrong amount, the wrong content, and the wrong timing. The amount should be absorbable, the content should be specific and useable, and the timing should respect both trainees' receptiveness and dignity.

It is difficult to think of a training situation where feedback is not indicated. The training design choice is what kind, delivered in what ways, at what times.

REINFORCEMENT

In the previous section we distinguisted reinforcement and reward. Reinforcement is the more important of the two.

Reinforcement is a response that occurs concurrently with or immediately after an action is taken. Positive reinforcement is anything that increases the likelihood of the action being repeated. Negative reinforcement is anything the trainee or subject wants to avoid, and that can be avoided by a change of behavior. There are three important implications of this definition:

- There has to be something to reinforce. Reinforcement only works on behavior that is already occurring (even if it is occurring sporadically).
- Reinforcement doesn't have to be pleasant to be positive, or unpleasant to be negative. Anything that increases the likelihood of an action being repeated is positive reinforcement, and anything that increases the likelihood of a change of behavior a negative reinforcement. Reinforcement is a purely operational concept.
- Reinforcement is different than reward or punishment. Reward and punishment occur after (often long after) the actions being rewarded or punished have been taken. And negative reinforcement, unlike punishment, can be "turned off" immediately by a change in behavior.

Reinforcement and feedback are intertwined. Reinforcement is mostly about motivation, feedback about changing observable behavior. However, feedback is often reinforcing (negative or positive) and reinforcement certainly changes behavior. When communicating feedback, the trainer's tone of voice, physical attitude, and facial expression can greatly vary the degree and kind of reinforcement. Feedback and reinforcement almost always interact. But there is a difference.

As there are two kinds of reinforcement, there are two modes for each kind, intrinsic and extrinsic.

Intrinsic reinforcement is when you feel good (or bad) inside because of what you have done, without any other person

reinforcing you. This is the simplest kind of reinforcement. You draw a picture, and you're happy doing it.

Extrinsic reinforcement comes from outside, whenever another person reinforces you. That it is another person is important to the definition of "extrinsic". If an action has a direct and obvious result, with an equally obvious desirability of outcome, then doing well or poorly is intrinsic reinforcement, even though the stimulus is external. For example, in basketball, shooting "free throws" provides immediate reinforcement. The stimulus is external - you make it, or you don't - but the reinforcement is internal.

Some research has suggested that if extrinsic reinforcement is applied to a behavior that had previously been motivated intrinsically, then when the extrinsic reinforcement is subsequently removed, intrinsic motivation to perform the activity drops off. In effect, extrinsic reinforcement has been substituted for intrinsic, and when the extrinsic is removed, the intrinsic is no longer there, or at least has been significantly dampened.

This is a concern when (a) trainees appear to be overly reliant on the trainer for reinforcement, even to the extent that they really just don't want to do it without reinforcement; and (b) the task is such that it is reasonable to expect it to be intrinsically reinforcing. When this is true, then a program of weaning trainees of all but the most important reinforcement is called for. After all, by doing so, you are reinforcing them in developing their own internal capacity for the task!

The research on whether extrinsic reinforcement decreases intrinsic motivation is controversial and intensely debated, though. Because the research results are so controversial, not reinforcing people to avoid decreasing intrinsic motivation should be done with care. As long as...

- The learners know what is expected from them.
- The trainer provides reinforcements that remain sincere, meaningful, and appropriate.
- The trainer is alert to, and doesn't allow, trainees to become overly reliant on the extrinsic reinforcements.
- The learners are not just doing the minimum necessary to get

the reinforcement.

... then extrinsic rewards are great.

Should one be cautious in giving out reinforcement because it might backfire? Or give it out like candy (which, in some cases, it might literally be)?

1. Sometimes people only work for the reinforcement, doing the minimum possible. If reinforcement is removed, they stop altogether. But these effects often are not long term, and the person will go back to their previous level without the reinforcer later.
2. If the intrinsic reinforcement is weak at the beginning, extrinsic reinforcement should be given freely. It helps to get people going, and can make a difficult task seem possible.
3. For some tasks, the work is not ever going to be intrinsically reinforced. Extrinsic reinforcement will be necessary as a structural part of the task.
4. The trainer needs to do his or her best to make reinforcement meaningful, precise, and well-timed. People detect insincerity even when they can't consciously put their finger on it. In one of those funny twists, the more reliable and generous the trainer is, the easier it is for trainees to give up reliance on the trainer's reinforcement.

Neither intrinsic nor extrinsic reinforcement is "better" than the other. Humans respond to a mix, and the particular mix should be planned according to the nature of the task to be trained and the goals of the training.

Unintentional, misdirected, and unusable reinforcement are common problems. The first occurs either when the trainer is responding without being conscious of doing so to some aspect of the trainees' performance, or when a trainee senses an unspoken attitude or reaction from the trainer. Misdirected reinforcement occurs when the trainer simply reinforces the wrong thing, whether due to error in timing, beliefs about what a trainee wants as a reinforcer, or even a misunderstanding about the structure of the task. (The trainer isn't perfect.) Unusable reinforcement can occur when the trainee perceives himself or herself as doing many things at once, and doesn't know what aspect of his or her performance is being reinforced; or, when the reinforcement itself is vague—was it

positive? Negative? Large? Small?

Reinforcement is such a general approach, and there are enough circumstances where even withholding reinforcement is in itself a reinforcer, that the only case where reinforcement won't be used is probably totally unsupervised task immersion ("push 'em off the dock style sink or swim"). Like feedback, the question is not whether to use reinforcement, but how to use it.

CONSISTENCY IN REWARDS AND PRAISE

Several training techniques including Attitude: Locus of Control, Contract Theory, and Socialization involve rewarding improvement or performance. Praise is part of the same process and can be a form of reward in itself. To help make rewards and praise effective they must be consistent.

The basis of consistency lies in a clear understanding of performance expectations, assessment of trainee capabilities, and knowledge of previous reward levels and types. Clear performance expectations mean performance itself can be praised and rewarded as distinct from improvement. Awareness of trainee ability leads to rewards and praise when improvement is shown and when effort is made. Remembering which rewards are appropriate for particular activities or at particular times helps to make them seem fair and worthwhile.

Avoid unintentionally rewarding unwanted behaviour or actions. Use appropriate training techniques to lift moods or disappointment. Be aware that simply paying too much attention to negative states or activities can itself constitute reward giving. This may result in a repeat of the negative state or action in order to gain the "reward." The best approach is to pay a lot of attention throughout all the training session. It is important also not to let moods and external circumstances interfere with reward giving. If praise or a reward has been earned it should be given even the trainer does not feel so inclined.

Determining when to give rewards for effort and improvement should be based on what is reasonable to expect from a trainee. It should also be calculated to produce more effort. If rewards are delivered too frequently, trainees have no incentive to strive, and the effects of rewarding will be diluted, even creating a loss of credibility. Rewarding trainees every time they accomplish a simple task will not be productive. A reward for successive accomplishments is likely to produce greater effort. Praise, as a lesser measure, can be used as encouragement along the way.

Remember that rewards are largely considered worthwhile based on the credibility of the reward giver. High praise or large reward from

someone ill-informed about the subject of training may not be as effective as that from an expert. In the same way, praise and reward from someone considered to be of high status may be valued more highly than from someone of equal or lower status to the trainee. This sort of factor can be another influence when rewards and praise are assessed for consistency.

Shaping is an allied technique, but has the aim of achieving successive approximations of the goal which is different from the consistent reward of effort. Information on feedback is useful for understanding the processes at work when rewards and praise are used.

TRANSFER

"Transfer" is what shows up in real-world practice as a result of training. The goal of training goal should be for the trainees to perform better out in the world. (Though this isn't always remembered as well as it should be.) The basic rule of transfer from training to practice is: The more similar the training is to the real task, the more complete the transfer.

Unfortunately, there's a trick built into that definition: What does "similar" mean? Superficial characteristics? Abstract processes? Same tools? Similar settings? Internal environment? All of the above, plus something else?

The significance of degree of similarity is keyed on the importance of the particular "feature" of the training situation relative to actual task performance. A "feature" is a dimension or an essential characteristic of domain.

Baldwin & Ford (1988) say that transfer happens when:

- There are identical stimulus and response elements in training and the job.
- The training covers general principles and not rote practice.
- There is variability in the problems encountered during training.
- There are several different conditions/situations for practice.

Noe adds that transfer is likely when:

- Trainees are confident that they can use the skills correctly.
- Trainees know how and when to use them appropriately.
- Trainees think they can do better on the job with the new skills.

Roulier and Goldstein (1991) classified the post-training transfer environment into:

- Situational cues of three kinds: (a) goals that serve as reminders to use the training; (b) social cues, both behavioral and the influence of peers and supervisors; and, (c) task and structure cues, that is, cues from the job itself.
- Consequences, including both postive and negative feedback, and rewards and punishments.

They found that both mattered significantly.

Tannenbaum and Yukl add that the postraining environment can:

- Encourage transfer through rewards and job aids.
- Discourage transfer through ridicule from peers.
- Inhibit transfer through lack of equiptment or opportunity to use it.

As an aside, while faithfully reporting their results, the author finds it hard to get excited by such recommendations, but perhaps they are less utterly obvious than they seem.

Noe stresses the importance of feedback from supervisors, peers, and subordinates. You have to have a positive social atmosphere in which to transfer. He also claims that it might help to provide organizational rewards to people who provide feedback and encouragement for use of new skills.

In summary, the fundamental rule of transfer is to make the training and training environment as similar to the actual task environment as possible.

There are two times to break this rule

1. When exaggeration can aid training, e.g., faster pace, more intensity, higher loading, greater demand for precision, etc. Not only can this increase capacity, it can make actual performance seem easier (because it is easier).
2. When more variation than is usually seen can aid training, by supporting generalization and distinction between the task's varying and invariant features.

SUMMARY OF UNIVERSAL TRAINING ISSUES

We've discussed the assessment of prerequisite skills and knowledge; expectations; motivation; goals; feedback; reinforcement; and transfer. We began this section by asserting that none of these were problems with definitive solutions, an assertion with which we hope to have satisfied the reader.

We're now ready to consider specific training methods and approaches.

USING THE GUIDEBOOK

In this section, we give an overview of ways to look at different kinds of training. We then describe how to locate specific kinds of training for specific tasks.

KINDS OF TRAINING APPROACHES

There are so many training approaches that an organizing perspective is helpful. One way to divide training approaches is between strategies and tactics. These are points on a continuum, which are easy to distinguish in the extreme cases, e.g., structured state-space differentials as a strategy, writing on the blackboard as a presentation tactic. (Actually, even this example is unclear—"writing on a blackboard" can in some cases be a strategy.)

Strategies can be roughly divided along two orthogonal dimensions: telling/doing, and modeless/modal.

Telling strategies involve discourse on the part of the instructor and reception on the part of the learner - that is, telling. Telling can include verbal and textual material, diagrams, pictures, and audio. Not to go too far off into the land of the abstract, but... Halliday (1975) categorizes seven language functions. He call four pragmatic: Instrumental, regulatory, interactional, personal. Three he calls mathetic: Heuristic, imaginative, and informative. Pragmatic functions orient and act. Mathetic functions create knowledge and move beyond the immediately referential. Bruner (1986) points out that another function must be added, the metacognitive capacity to reflect on language and telling as a subject in itself. Telling can apply any or all of these functions; in a classroom setting, most of them will be.

"Doing" strategies involve some form of demonstration or direction on the part of the instructor and active imitative or goal-seeking behavior on the part of the learner. Doing can involve physical mimicry, performing experiments, practicing motor skills, using simulations, or constructing artifacts. Of course, it can also involve telling; for example, teachback, in which the learner plays the role of instructor, is a form of doing.

Telling and doing are meant to be reasonably broadly construed. It should not be thought that telling is somehow passive, in contrast to doing, which is dynamic. Both are active. A Socratic dialog is a form of telling. The distinction is that in telling, internal constructive action is required of the learner, while in doing, both internal and

external constructive action is required.

Modeless strategies present material in the "timeless present," i.e., as facts, assertions, or operations to be internalized and reliably reproduced. Operationalizing F = MA with respect to various physics problems is an example. The feeling of modeless strategies is that the material is somehow out there in the world, independent of any action or intention of the learner.

Modal teaching applies stance marking (Feldman & Wertsch 1976), that is, use of linguistic or other tokens of uncertainty and probability to invite negotiation of, and responsibility for, meaning. "Stance marking" may sound like what dogs do to fire hydrants, but it is a real thing. Bruner *op cit.* gives the example of his fifth grade teacher, Miss Orcutt, making the statement "It is a very puzzling thing not that water turns to ice at 32° Fahrenheit, but that it should change from a liquid into a solid." Instead of taking a modeless approach and presenting a fact, and backing it by authority, she invited her students to share her fascination with the (rather bizarre, if we weren't so habituated) phenomena of state transition. Modeless strategies are concerned with truth, while modal strategies are concerned with meaning. Looked at from a different perspective, modeless strategies rely on authority, while modal strategies require at least some degree of learner initiative.

That presentation is pretty biased, though. It makes modeless strategies sound unimaginative, authoritarian, and dull. That's unfair. Modeless strategies are really *efficient,* and sometimes both teacher and learner just want to get the facts across in as straightforward a way as possible. If all you're trying to do is tell some trainees where the on/off switch is, you're going to annoy them if you invite them on an Imaginative Journey into the World of Power Switches.

Organizational strategies are slightly simpler. We distinguish structural, discovery, and narrative.

Five aspects of the structural strategy (from [Meyer 1975]):

- Covariance, a causal relationship between antecedents and consequences.

- Comparison, a reference to known structure(s), either metaphorical or analogical.
- Collection, clustering related concepts or operators, in time, space, or function.
- Description, provision or general statement followed by supporting evidence.
- Response, pairing problem and solution, question and answer, or remark and reply.

Discovery techniques can be "pure," guided, or expository. In pure discovery, the learner is set in the learning environment to find on his or her own those regularities that comprise the training objective. In guided discovery, the learner is given cues to focus search. Both pure and guided discovery are inductive approaches. Conventionally, in inductive approaches, the target rule, concept, or procedure is provided after the learner has discovered (induced) the underlying structure. In expository discovery, a deductive approach, the rule is provided at the start, and the discovery process lies in deductively finding its correct application.

The narrative approach provides a skeletal plan or schema which can be elaborated and refined. Narrative seems the most flexible of the organizational approaches.

Presentation tactics for instruction include:

- Classroom (verbal, written, diagrammatic, pictorial/image, auditory).
- Structured environment (guided and/or discovery).
- Demonstration.
- Modeling and simulation (real-world, computer-based).
- Field exercise (guided and/or discovery).
- On-the-job training (OJT).
- Hybrid approaches such as field class, SAFOR, or classroom role-playing (for instance, teachback).

THE WEB SURVEY

To use the automated approach to generating ideas for training approaches, you can take our survey and we will make some recommendations. Following are the statements with which you will be asked, in textual form. For each statement, you will be asked to register a judgement of the degree to which the statement is true for you task.

1. The task to be trained performed in a physically stressful environment.
2. The task to be trained performed in a physically dangerous environment.
3. A high degree of physical skill is required for the task to be trained.
4. The task to be trained needs to be performed when fatigued.
5. There are large variations in information reliability in the task to be trained.
6. There is a high degree of event variability, that is, big differences between minor and major events, in the task to be trained.
7. The consequences of errors are very serious in the task to be trained? ("Serious" ranging from embarrassment or annoyance at one end to death at the other.)
8. Degree of motivation strongly affects performance in the task to be trained.
9. Individual autonomy is an integral part the task to be trained.
10. Many different kinds of things must be done at once in the task to be trained.
11. The task to be trained requires extended vigilance.

12. Very high levels of expertise can be achieved in the task to be trained. (Concert musicians and neurosurgeons are examples of high-expertise practitioners.)

13. The task to be trained requires a high degree of intellectual skill. (Scientific research is an example.)

14. Real-world experience is vital to become truly qualified for the task to be trained.

15. The ability to explain is very important in the task to be trained.

16. A very large volume of factual knowledge is needed for the task to be trained.

17. A very large volume of procedural knowledge is needed for the task to be trained.

18. Self-management - working despite stress, concentrating despite distraction, maintaining composure - is critical to good performance in the task to be trained.

19. Mutual monitoring among teammates is very important in task performance.

20. Feedback among teammates is very important in task performance.

21. Communication among teammates is very important in task performance.

22. Reciprocal backup among teammates is very important in task performance.

23. Interdependence among teammates is very important in task performance.

24. Predicting teammates' behavior and intentions is very important in task performance.

25. The extent to which a teams "jells" is very important to task performance.

26. The quality of leadership has a very strong or even decisive effect on the performance of the team.

TRAINING METHODS BY CATEGORY

These are the covered training methods, arranged in categories. The next section provides an alphabetical list.

Learning physical and general procedural skills
Adaptive Training
Automaticity
Behavior Modeling
Break Up Practice
Enactive Mastery
Establish An Environment
Feedback - Withhold It
Feedback- Delay It
Games And Simulations
Learn By Doing Only
Let Trainee Become Master
Limit Introduction
Match Instruction And Practice
Mental Simulation
Overlearning
Physical Guidance
Practice Alone
Shaping

Memory
Automaticity
Behavior Modeling
Computer Aided Instructions
Chunking
Method Of Elaboration
Method Of Loci
Mold Mental Models
Networking
Planned Cues For Memory
PQ4R
Recoding
Visual Cues As Prompts

Learning complex intellectual material
Automaticity
Behavior Modeling
Computer Aided Instructions
Deliberate Practice
Games And Simulations
Let Trainee Become Master
Mental Simulation
Operationalize Definitional Concepts
Overlearning
Practice Alone
Self-Explanation
Solve Without Examples

Developing high levels of expertise
Adaptive Training
Attitude - Locus Of Control
Automaticity
Deliberate Practice
Dont Take Your Time- Stress
Enactive Mastery
Establish An Environment
Games And Simulations
Let Trainee Become Master
Mental Simulation
Mentors
Overlearning
Practice Alone
Self-Explanation
Sequence - Hard Or Easy
Shaping
Solve Without Examples

Dealing with stress
Adaptive Training
Attitude - Locus Of Control
Automaticity
Dont Take Your Time- Stress
Enactive Mastery
Establish An Environment

Games And Simulations
Overlearning
Stress - Criterion Practice
Stress - Emotional Training
Stress - Full Information
Stress - Graduated Training
Stress - Phased Training

Group and interpersonal skills
Behavior Modeling
Contract Theory
Establish An Environment
Games And Simulations
Mentors
Paired Post-Training
Path-Goal Theory
Sequence - Hard Or Easy
Shaping
Stress - Emotional Training
Summarize For Class
Teams - General Methods
Teams - Cooperative Controversy
Teams - Cross Training

Learning when the actual environment can't be used
Attitude - Locus Of Control
Automaticity
Computer Aided Instructions
Establish An Environment
Games And Simulations
Mental Simulation
Overlearning
Stress - Criterion Practice
Stress - Emotional Training
Stress - Full Information
Stress - Graduated Training
Stress - Phased Training

Long-term learning in organizations
Attitude - Locus Of Control
Behavior Modeling

Computer Aided Instructions
Contract Theory
Deliberate Practice
Games And Simulations
Making Training Seem Important
Mentors
Paired Post-Training

Transfer
Automaticity
Behavior Modeling
Enactive Mastery
Establish An Environment
Games And Simulations
Mental Simulation
Paired Post-Training
Stress - Criterion Practice
Stress - Emotional Training
Stress - Full Information
Stress - Graduated Training
Stress - Phased Training
Transfer - Immediate Practice

TRAINING METHODS ALPHABETIZED

These are the covered training methods, as an alphabetical list.

Adaptive Training
Attitude - Locus Of Control
Automaticity
Behavior Modeling
Computer Aided Instructions
Chunking
Contract Theory
Deliberate Practice
Don't Take Your Time- Stress
Enactive Mastery
Establish An Environment
Feedback - Withhold It
Feedback- Delay It
Games And Simulations
Groups- Cooperative Learning
Interactive Imagery
Learn By Doing Only
Let Trainee Become Master
Limit Introduction
Making Training Seem Important
Match Instruction And Practice
Mental Simulation
Mentors
Method Of Elaboration
Method Of Loci
Mold Mental Models
Networking
Operationalize Definitional Concepts
Overlearning
Paired Post-Training
Path-Goal Theory
Physical Guidance
Planned Cues For Memory
PQ4R
Practice Alone
Recoding

Self-Explanation
Sequence - Hard Or Easy
Shaping
Socialization
Solve Without Examples
Stress - Criterion Practice
Stress - Emotional Training
Stress - Full Information
Stress - Graduated Training
Stress - Phased Training
Summarize For Class
Teams - General Methods
Teams - Cooperative Controversy
Teams - Cross Training
Timing of Practice
Transfer - Immediate Practice
Visual Cues As Prompts
Visual Cues For Navigation

ADAPTIVE TRAINING

Description

Adaptive training makes training more doable for trainees by temporarily making the task easier, without breaking it into components.

How to do it

As its name suggests, adaptive training is the process of adapting training to the current ability level of your trainees. You begin with a simplified version of the task. As trainees gain proficiency, you add complexity. In this way, you step them up until they are doing the actual task.

This is distinct from breaking the task down into parts. Here, the trainees are doing the actual task with the actual goals throughout their training. The task is simply adjusted so that it is at the right level of difficulty for the trainees. Maintaining the right difficulty level is an advantage of adaptive training.

If trainees need to learn to do two tasks at once, you need to assess the interconnections between the tasks. If they are loosely bound, you may be able to adjust each task based on its own internal complexity. If the tasks are tightly interdependent, you may have to adjust both at once, each relative to the demands of the other.

Indicators

This provides the learner with a task that is not too difficult to master, when the actual task is too difficult to master. This approach is especially appropriate when the task is not easy to break into components.

Counterindicators

Adaptive training is an alternative to breaking the task into subtasks. For some tasks, it is better to teach the subtasks and their integration.

When using adaptive training, you need to be careful that your trainees don't learn to do the task wrongly, or learn to respond to particular stimuli in the wrong way, which they'll have to unlearn to perform the full task.

It is also true for this technique that if it is difficult to accurately gauge how well trainees are doing, then it will be even more difficult to accurately adapt the training to their needs. If that's the case, looking again at breaking the task into components might be worthwhile.

Common problems

If you find that people are unable to keep up, don't blame the trainees ("The people we get nowadays! Why, in the *old* days...!") Make the task easier. But if they are bored, make it harder, because you want to challenge them. It's a fine line.

If you find that the student is not really ready to move on, but believes that he or she is, you will need to find a way to motivate them to continue working on the current level of the task even though they think they don't need it. This can be hard to do.

If the trainee is able to do most of the task but still needs work on a few aspects, if possible isolate those elements and work on them. This is really component training, rather than adaptive. However, that may be appropriate if you can identify specific elements that in fact can be isolated and practiced.

Related techniques

Shaping
Easy first/Practice in parts
Deliberate practice/Practice in parts
Enactive mastery
Stress - how to practice
Expectations about training
Needs assessment
Stress—Phased training
Stress—Graduated training

References

Holding

ATTITUDE: LOCUS OF CONTROL

Description
This approach helps trainees to understand that performance and events depend on what they do, that the "locus of control" lies in themselves. People who believe success results from their actions achieve better results than those who tend to blame failure on luck, fate, other people, or circumstance.

How to do it
Simply explain the desired attitude and show how it applies to the task in hand. Identify points where circumstance might be blamed and show how skill and concentration are key factors. Notice and correct inaccurate attributions to luck.

Create an environment where learners are coaxed to try their best. Leadership is important to show the natural way to attribute results is to oneself. Realism is important, though.

This technique is best integrated with others, including socialization and lead-by-example.

Indicators
You can use this approach when someone is making a lot of excuses and or not taking responsibility for what they do. They should be encouraged not to do so, and especially to see task-relevent instances of cause and effect with respect to their actions.

It is a good, basic technique to influence the attitudes of your trainees, or to help set up a positive atmosphere for training.

Counterindicators
This requires fairly high trainer skill, and content may not always be appropriate.

Common Problems
Since this type of training deals with personality, you may find attitudes are ingrained. Persistance and good socialization will help to overcome this. Allow plenty of opportunity to identify when success is due to individual actions.

Related techniques
Socialization
Goals - Learning Vs Performance

References
Noe

AUTOMATICITY

Description
Often tasks have elements that can be done automatically, that is, as a response to stimuli without having to think. Learning automaticity is the process of practicing an initially conscious action or sequence until it can be performed without conscious attention. Automatically, appropriately applied, not only leads to good performance of the automatic reaction, but also frees up mental resources to be focused on other things.

Automatic tasks are often quite simple, but very complex behaviors can become automatic - such as driving or playing some kinds of musical passages.

Automatic responses can be separated two groups. One is where you automatically react to a stimulus, e.g., as competitive athletes must in some circumstances. The second is where an automatic sequence of behaviors is followed after a conscious initiation, e.g., tying shoes. The elicitation of the behavior may also be automatic, though subject to normal intentional control, but once the process is started, it runs itself. (If the training goal involves sequence, the section on Overlearning may also be applicable.)

How to do it
There a a number of approaches to training automaticity.

1. Finding things to automatize

Use places where novices have problems and experts don't, or where novices are affected by stress and experts aren't, to find things to train. For example, if experts can do something but can't tell you how to do it, for example if only their hands know how to do it, then it is likely that some or all of the task can be made automatic.

The responses don't have to be unique, but the more consistent they are (i.e., the more often the response you are trying to train is appropriate to the stimulus) the easier they are to learn and the more useful the training will be.

2. Repeated practice

Automaticity results from a lot a practice. The trainees must be able to do the task correctly. Then they repeat it endlessly.

If there are components to the task, train them first, then integrate them. The way that some complex automatic tasks become automatic is that you learn to do a whole bunch of simple things automatically. If you are trying to train someone to do something automatically, you want to do it starting with simple rules and reactions that they can get right, and then make it more complex once they learn the simple material.

3. Point out relevant cues

Sometimes, you may not be able to actually tell the learner any useful rules to use. If not, don't give up. Just identifying the stimuli that are predictive may help. Let their brains figure out the rules on their own. (It may be that you don't know the rules because your brain figured them out without telling you what they were).

For example, in volleyball, just say "I want you to really look at their armswing really close today," and your trainees may just learn to pick up important cues and react just by noticing what happens, when without focusing on it they might never have noticed it. You don't have to tell them the actual rules, see, you just tell them what the antecedents are so that they can figure the rules out.

4. Accuracy

Do not sacrifice accuracy for speed, especially in the beginning. Speed will develop. In fact, do not sacrifice accuracy for anything.

Tannenbaum and Yukl say that if automatic elements of the task are learned incorrectly, they will be remembered that way too. Once you learn to do something automatically, you stop learning unless you are forced to change your ways. Much better to learn things right the first time.

5. Do not change the response

Kylonnen and Alluisi point out that it is a very bad idea to train people to react in a certain way to a cue (automatically), and then as the learning progresses, make them change the way they react. Avoid changing requirements midstream. This is relevant to tasks where

you are training simpler versions first, or when you are training a part of a task that the person is inclined to do differently because other factors are not being included.

6. Make the practice environment realistic.
Present the stimulus and have the trainees practice in a realistic setting. This helps with generalization/transfer.

If you can't actually present the cues in a realistic setting (for example, you can't light a person on fire to have them practice "stop, drop and roll"), then other routes to automaticity must be pursued. Tell them what to do, use mnemonics, or use mental simulation (have the trainee imagine being in the actual situation and reacting appropriately).

7. Let them know how they're doing
Along with reinforcement, giving trainees accurate feedback is very important for training people to do things automatically.

8. Increase the frequency of uncommon events
Once basic automaticity is achieved, make sure that uncommon, but consistent, events are experienced often enough that they can be automatized - by making them occur on purpose, speeding things up, or other changes in the environment.

9. Complex rules
Sometimes you have fairly complex rules. For example, a baseball player does not have time to figure out what to do after the pitch is thrown. He must react automatically. But baseball players use the information about what is going on in the game and about what the ball is doing to decide whether to swing, and how to swing (making sure to contact the ball at the same time). The rules they have to follow are complicated - a lot of things influence each other, the cues are not easy to read, and it is a hard task that has to be done automatically. The reasons why they do or don't swing are complex, but are based on some set of automatic rules that they have learned. If you are forced to train something like that (heaven forbid), you can still train it automatically. You can try to figure out individual rules, and implement them (e.g., "if the pitcher twists his wrist, expect x"). On the other hand, you can also train the person to do it without being able to give them actual rules: You can just give them feedback

and instruction and let them learn the rules subconsciously. This doesn't take advantage of most of the techniques in this section, but humans are good at automaticity.

10. Segmenting

Train the hard parts of a complex task in greater depth than the easy ones. This may sound like the opposite of automization. It is often true that saying something is "complex" really just means that it is hard to learn - either the set of rules to follow based on the cues is complex and subtle, or because the behavior is hard. Thus, do the hardest thing the most.

11. Invent inconsistency

Training them in less than perfectly consistent circumstances may help them to be even better at responding once you put them in a context where there is great consistency. So if you have them have to do a little mental processing to recognize that a certain response is appropriate, and then make it so that it always works, their automatic processes will be especially honed.

This is best to do after they have learned to do the response automatically and correctly in the first place.

12. Train with a timer

Another way to make the training especially strong is to speed it up. For one thing, this forces trainees to use automatic processes instead of relying on cognitive resources. You might even speed things up beyond the speed that naturally occurs in the task. People have a lot of potential. If they can learn it so well that the actual task is a cinch compared to the training, then they will do well on the task. If you don't challenge them, though, that potential may never be realized, because people tend to stop improving once they don't need to anymore.

13. Go all the way

If there is something you can identify as being a good candidate for automaticity, make sure you get all the way to automaticity. it is worth the extra effort.

14. Scripting

If you want to learn to do a sequence of behaviors automatically, you should make sure that each step in the sequence automatically triggers the next, so that you don't have to think to keep the sequence going.

If there are components of the sequence that need to be practiced on their own for the trainee to be able to do them right, then they should be practiced. But after that, the trainee should just do the full sequence, over and over again. And again (see overlearning). And to increase transfer and generalization they should do it in different contexts, both circumstantial and temporal (assuming temporal generalization is a desired outcome).

Indicators

Tasks that include standard procedures or easy elements or require repetition can be automatized.

Complex behaviors can become automatic, if they simply consist of thorough sets of rules and signals and procedures.

In situations of high stress, automatic responses and scripting will be particularly useful. They require less control and fewer cognitive resources - meaning that (1) they are harder to disrupt by stress, and (2) they allow you to think about other things, making it easier to do the task.

If you find that novices find something very hard that experts can do easily, or if experts can do it but can't tell you how to do it, or if experts are unaffected by stress when doing something, then it is a good bet that they are doing the task automatically, so you may want to try to train the novices to do it automatically too.

Counterindicators

The more consistent a task is, the better a candidate it is, and conversely, the more variable, the less suitable. If every time you see a gun, danger is present, then it is not a bad idea to train the automatic response of alertness and preparation to flee at the sight of a gun. However, if every time you see a knife you have the same reaction, the kitchen is going to become an overly exciting place. You want to use automatization only if given a certain cue (or set of cues) only one response is appropriate. If you are training a sequence of

behaviors, you want to make sure that once the sequence is initiated, it is only supposed to go one way, because it is only going to go one way.

A drawback is that this approach is inflexible. Automatic responses are likely to be elicited even if they have become inappropriate. More worrisome still is lack of flexibility when there is a sequence of behaviors (or script) that you have learned. If the set of steps doesn't work, you are going to do them anyway, or else not know what to do. If you get interrupted in the middle, you may have to start over, just like tying your shoes. If this is not a problem, then it could be used for anything where there is a single pattern that is always used to do a certain task.

Common problems

Do they do the same thing in training of the components as they do when they are actually doing the task, or do they revert to some other behavior? Have they already learned to do things wrong, or to ignore certain things? Have they stopped learning new responses and started just getting better at the old ones? And are the losing motivation (training the automatic parts is probably going to be fairly boring and not get them spectacular results in the short run). Are they learning to do things wrong automatically?

Related techniques

Overlearning
Shaping

References

Rogers, Maurer, Salas, and Fisk
Tannenbaum and Yukl
Kylonnen and Alluisi

BEHAVIORAL MODELING

Description
Behavior modeling takes advantage of the human ability to observe and mimic. The trainer performs the task with the trainees watching. The trainees then imitate the trainer.

Behavioral modeling should be preceded by an explanation of what you want them to do or learn. While the demonstration is being given, it may be appropriate to highlight key elements. If the demonstration is live, it may be useful to repeat portions of the demonstration while the trainees practice.

Behavioral modeling has been advocated as a way of learning interpersonal skills. It is also commonly used to teach physical skills.

How to do it
There are five steps in behavior modeling:
1. Modeling. Present a demonstration (live or on tape) of a skilled performer showing the desired behavior. During the demo, point out the important elements, things to be learned, how it all fits together, things to remember, and if appropriate, things to not learn.
2. Help them to remember and understand what they saw.
3. Have the trainees practice. The more the better.
4. Give them feedback on their practice, including (as appropriate) repeated exposures to the modeling. One approach to this is to allow trainees to watch themselves on video, with expert commentary reinforcing correct behavior.
5. Help them transfer it to the real world.

Behavior modeling is a good technique when an algorithmic approach to the task - that is, an approach that can specify each step - is not available. Behavior modeling is good even when there are few concrete guidelines as to how something should be done, and trainees need to learn skills that require flexible, adaptive behavior. Behavior modeling should be used if for the particular task, it is simply easier or more apt to demonstrate than to tell. This is certainly true of many physical skills, and in domains like music or surgery, verbal instruction without hearing or seeing would be inadequate.

When behavior modeling is used to train social interaction skills, the trainees should be exposed to the general principles, see these modeled in a variety of different situations, and then be given the opportunity to practice and to devise alternative ways to apply the principles in various situations.

When trainees are imitating someone skilled, they perform better with the skilled model is observing. This result seems like it might be domain-sensitive, though. While it's easy to picture for athletes being observed by their coaches, it's harder to picture managers being more effective in talking with employees while their own managers are looking on.

It may be hard for trainees to notice or to pick out the most important elements. It is a good idea to point out the things you most want the trainees to see, just as or immediately after they happen in the modeled behavior. This is especially true for key behaviors that are difficult to see or not naturally distinctive.

The "drop-step" in basketball is an example. Most observers, when shown a drop-step, will simply see the player with the ball turning quickly around a defender. However, an essential part of the drop-step is to be positioned correctly at the initiation of the move, and in making the turn to use the hips and butt as a lever to force the defender away from the direction the player wishes to go. This use of the hips must be pointed out and explicitly practiced.

Without articulated learning points, there can be problems. For example, one study followed managers who were taught how to reprimand employees. In the group without learning points, there was marked decrease in the amount of positive reinforcement given out by the trainees when they returned to their jobs. The model had demonstrated reprimanding, but what the trainees apparently learned was "be mean", part of which was withholding positive reinforcement from their employees. Learning points help you make sure your trainees correctly understand what you are trying to get across.

Negative learning points can also be used. If there is only a single model available, he or she may unintentionally add idiosyncratic elements to the demonstrated performance. If this is the case, it is

appropriate to point out to the trainees those things that should not be imitated.

As long as the appropriate principles are being followed, let the trainees develop their own rules. They will come up with rules that are not necessarily perfect, that may be inefficient, but they will remember them. It is fine to suggest rules and guidelines, but it is important to allow them to figure out their own. If this really does not seem true for the particular task to be trained, then behavior modeling may not be an appropriate training technique.

Behavior modeling relies on the trainees ability to observe, imitate, and self-correct. The more accurately trainees can observe themselves and compare their own performance with the models', the more quickly they will be able to advance. Depending on the task, any of mirrors, audio tape recording, videotape, or film may be useful. Decker found that combining videos of trainee performance with expert commentary "enhanced reproduction skills" (1983).

Indicators

If it is harder to describe how to do something than it is to show it, behavior modeling is appropriate. And, there are some things you just can't say. Again, behavior modeling is called for.

Mills and Price claim that behavior modeling works best for skills that are concrete, and for which there is one best way to do it, with little variation. There may be some unintended irony here, in that Mills and Price advocate behavior modeling as a technique for training managers in social interactions. On the other hand, Tannenbaum and Yukl call for behavior modeling when there are not concrete guidelines as to how something should be done, and trainees need to learn skills that require flexible, adaptive behavior. These apparently opposing views may not be so far apart, though, since Mills and Price were considering physical skills, while Tannenbaum and Yukl studied social skills.

Counterindicators

If it is possible to simply explain what you want the trainees to do, and then let them practice, that will be more efficient than having them try to pick up cues from a person modeling the behavior. Behavior modeling is of course a bad choice if task performance is not particularly visible. It would be difficult all around to teach math with

behavior modeling.

Some research suggests that behavior modeling works best for trainees with moderate to high self-efficacy. Those low on self efficacy were better off with one-on-one tutorial.

Common problems
People can learn any number of things that you do not intend for them to learn. Having the model (or better yet, different models) perform the target behavior repeatedly lets the learner see which elements remain constant (and are therefore the important ones.)

Related techniques for this training problem
Physical guidance
Heuristics - Don't take your time
Lead by example - Behavior
Lead by example - Attitude
Feedback - Action versus learning
Feedback - Delay it
Feedback - Withhold it
Mentors
Teams - Cooperative controversy

References
Tannenbaum and Yukl
Mills & Pace
Holding
Latham

COMPUTER AIDED INSTRUCTION

Description

There is an ever increasing use of computers in instruction. This section has some information about when computer aided instruction (CAI) is most beneficial. How to actually design and build computer-trainers is covered in other sections. This one tells you when they may be useful and which type is best.

How to do it

Over the last fifteen years, four general approaches to active computer-assisted instruction have emerged. (By active we mean to distinguish these approaches from simply using the computer as a media for information presentation.)

The first to emerge was model tracing [Anderson et al 1985]. Model tracing assumes that there is a right way to perform a task and attempts to determine where the student is in the problem-solving sequence, and how far he or she is from the correct protocol. The advantage of this approach is that it is fairly simple. The disadvantage is that it puts the burden on the student to figure out how and why he or she was on the wrong track and how to return to the correct approach.

The second approach is reconstruction [Naveh-Benjamin et al 1986] This grew out of an awareness of the problems with model tracing. The goal of reconstruction is, as the name suggests, an attempt to induce a model of what the student must have been thinking to have shown the observed behavior pattern, that is, to reconstruct the students model of the domain and process. If model tracing is perhaps too simple, reconstruction is too complex. In very tightly constrained domains, where all specific behaviors have unique causes, reconstruction is ideal. But for the great majority of domains where the same behavior can occur for many different, even unrelated reasons, reconstruction flounders.

In response to this problem, issues recognition begins by constructing an error space in parallel to the normal desired performance space [Rodolitz & Clancey 1989]. It assumes that there are a set of typical failings or break downs in understanding. Then

the user's progress is monitored, and when a discrepancy arises the program attempts to determine which typical failing is present. Remediation specific to that particular break down is supplied.

The most recent and successful approach is our choice for the proposed work: abstracted problem spaces, which are actually not so abstract as they may sound. The basic idea is simple. In any problem solving activity, there are likely to be conditional steps in the process of solving the problem. At each step, certain factors are relevant, others are not. Some kinds of data are germane, other data not. Some operations are applicable and useful, others not. In ad di tion, there are likely to be some markers which dis tin guish each particular stage of prob lem solving, and there are also likely to be markers for valid times to make a transition to another problem solving step (or space, a term borrowed from mathematics). The process of abstracted problem spaces is to characterize these steps, using cognitive task analysis [Lesgold et al 1986], and then to construct an environment in which learners can realistically practice, exercise, and experment in the various spaces.

These are all approaches to AI-based CAI. Most CAI is based more on the beliefs and tastes of the designers than anything else, though. Not surprizingly, some of it is really good, and some is less good.

After selecting the CAI mmaterial, provide trainees with CD-ROM and computer equipment, and allot a time for completion of the chosen material. Some studies have shown that a CD-ROM is better than lecture, text, videotape, or on the job training, though this result is more than mildly controversial. It has been shown that the more interactive the CD, the better. Note that low variability in performance has been found to be due to most people doing well.

Accountability is held to be important. For this reason, it is probably best to be prepared to follow up with short, but comprehensive quiz material and not to rely entirely on interactive correction built in to the program.

Indicators

Those people who find learning difficult - not people who find the task to be learned hard - do better with highly structured instruction,

broken down into sequences of simple units. This is something CAI delivers.

This method of training is easy to provide since it relies mainly on equipment alone, yet instruction is still expert. CAI is thought to be suitable when you are not planning a lot of training, when the training does not have to be in depth, and when the training is of an exact, set nature.

Counterindicators
Successful CAI relies on the choice of an appropriate CD-ROM. Considerable investigation may be required to find this.

CAI is not usually considered helpful when training needs to be flexible or customized or both.

Common problems
The CD-ROM is boring. High interactivity is considered to be the key factor. Good choice is essential also to ensure that the software is pitched at the right level of difficulty. It is also important that CAI equipment runs at adequate speed.

Related techniques
Games and simulations

References
Fletcher 1990
Tannenbaum and Yukl
Latham

CHUNKING

Description

There is only so much you can remember at one time. If you can group different pieces of information into packets, there will be less to be remembered (without losing information).

Chunking is normally discussed in terms of the aid it gives to short term memory, and Kyllonen and Alluisi are no exception. However, they do indicate that it helps with long-term learning, especially in the case where you make meaningful chunks. Newell claims that chunking is a basic human learning mode.

How to do it

You can use chunking to quickly encode or memorize things. So if a phone number is 2300489, one thing you can do is think of it as 23, 004, 89, that is, three numbers instead of 7.

Another approach is to look for familiar chunks or to add in meaning. So, 004 could be like James Bond 007, except that it is secret agent Byron Scott (a basketball player who wore the number 4). And you can also remember that the number starts with the first ascending even-odd single digit pair (23), and ends with the last one, (89).

When there is something that you are trying to keep in working memory, or if you want to learn something and be able to recall it later without it remaining in working memory, chunking can help, especially if you form meaningful chunks.

Related techniques

Those in these sections and the sections about complex memory tricks.

References

Kyllonen & Alluisi

CONTRACT THEORY

Description
This approach involves psychological contracts. An understanding is established about what is expected of the trainee and what he or she can expect in return. Agreement is reached that continued improvement and training will be rewarded.

How to do it
Before training starts make your expectations clear. Outline what actions are desired and ensure that rewards or advancements are considered fair, meaningful, and desirable. Rewards can simply be related to the activity undertaken, such as assignment of key roles. Psychological contracts are established by use. Don't say it if you aren't going to do it.

Be consistent. Contracts of this sort should apply in the long as well as the short term. Rewards can change to suit progress in training, but always ensure they are contingent upon clear learning goals. Improvement should be the major factor to be rewarded. This accomodates trainees of different skill levels.

Indicators
Contract theory can work as a specific application of a general management promise to reward training. It is also useful in any long term or intensive training session. It may also serve as a helpful approach when training is hard, inherently dull, or taking place in adverse conditions.

Counterindicators
Contracts may not help when training is very short and/or easy, or when rewards are difficult to determine.

Common problems
If learning goals are not clear, resentment can be created as rewards are not forthcoming when expected. Care should be taken to avoid creating favorites. Keep in mind that improvement is more important than absolute standards.

Related techniques

Making training seem important
Choices about training
Establishing a positive environment

References

Noe et al

DELIBERATE PRACTICE

Description

Deliberate practice is is the process of isolating the elements of the target task most in need of practice, and practicing them methodically and consistently until they are thoroughly mastered. Deliberate practice is iterative: The next step is to identify the next element of greatest need, again to be mastered through concentration and diligence.

Deliberate practice is highly structured, focusing intensely on improving performance. If it seems redundant to ascribe improvement to a training approach, remember that for many team training approaches, the goals include intangibles such as team-building, development of trust and appropriate expectations, sensitivity to monitoring and signaling, and so on. In contrast, deliberate practice is concerned with observable, tangible, measurable skills.

There may be social and team tasks for which deliberate practice is impractical, or not sufficient in itself to achieve mastery. But for individual skills, it is the best way to improve, and the only way to be the best.

How to do it

Six preconditions are necessary for deliberate practice:

1. A well defined task. The nature and limits of the task, and the criteria for good performance must both be known. More than just "known," they should be clearly apparent.
2. An appropriate level of difficulty. The task must be difficult enough to justify the practice, but not so difficult (or so hard to decompose into practicable chunks) that it can't be approached.
3. Informative feedback. There must be a means by which the practicer can clearly discern the difference between current and desired performance. The more immediate the feedback, the better.
4. Opportunities for repetition and correction of errors. The practicer must be able to practice the hard parts frequently and repetitively.
5. A high level of motivation. The learner needs to be able to attend consistently to the most difficult parts of the task, in effect to spend most of his or her practice time doing what he or she is

worst at. An abundant fountain of motivation is necessary, since the the focus is consistently on the least obviously rewarding parts of the task.

6. An unflagging willingness to exert effort to improve. Deliberate practice is hard work, and must be consistent, independent of whether the learner happens to be enjoying the process at a given time or not.

Matching the six preconditions, there are six steps.

1. Define the goals. These should be as specific as possible, and should be goals that can be accomplished in the immediate or near-term future. While these goals should fit into a long-term progression, the current step is to define the immediate goals.
2. Select the practice targets, which may require decomposing the task into practicable sections.
3. Understand the performance criteria. Develop clear and directly measurable criteria by which progress and performance can be judged.
4. Select the strategy and focus for practicing the task section. "Strategy" might be the proportion of time to be spent on different aspects of achieving a goal, or the mix of isolation and integration, or any one of a number of task specific things. "Focus" would be the emphasis within the practice chosen to satisfy the performance criteria, whether this involved overcoming a weakness or refining a strength.
5. Establish the conditions for practice. Where, when, and for how long. "How long" is discussed below. Practicing alone is a frequently mentioned element. One study found that differences between musicians in time spent practicing alone correlated strongly with their performance levels, but that total time spent playing music did not.
6. Practice the right amount, concentrating, until mastery is achieved. The "right amount" is also discussed below. Concentration is the key—when you can't concentrate any more, stop! Starkes et al found concentration to be the most important element of deliberate practice, the only element which is absolutely essential. Galamain and Auer found that when concentration wains, failure to stop practicing can actually lead to a decline in performance.

To make some of this more concrete, here's a worked out example.

First, a classical guitarist decides that developing an excellent tremolo is the next goal. (A tremolo is a rapid repetition of a single note, or occasionally of two notes. Used sparingly, it can create a very beautiful effect on the guitar.) Next (Step 2), the guitarist decides to alternate practicing evenness of timing and of volume, concurrently alternating between completely isolated tremolos and one or more tremolo-dependent songs. Third, the guitarist considers the criteria—evenness of both volume and timing, control of tone color, integration of arbitrary thumb movements with the tremolo (which is typically played with the first through third fingers). Fourth, a strategy of beginning with tightly focused practice on timing and volume evenness, then intermingling that with work on songs that exercise the thumb and require control of tone color and musical expression. The focus will first be on feeling the tremolo in the fingers, then achieving automaticity, where the hands automatically obey the musical intention.

In the fifth step, the guitarist has a regular, quiet and infrequently disturbed practice area already, and decides that an hour a day is the maximum that can productively be spent on the tremolo studies. The musician is in the habit of morning practice, and will continue with that.

Finally, the sixth step. The practice is begun and pursued. Concentration is monitored carefully, since the simple repetition required to perfect the tremolo doesn't provide a great deal of intrinsic variety. When the player is satisfied that temporal and volume evenness has been achieved at a wide enough range of metronome settings (both listening while playing and recording may be used to this purpose), songs are introduced: Tarrega's *Recuerdos de la Alhambra,* Barrios' *Una limosna por el amor de Dios.* Again using both the live sound of the playing and recordings, the guitarist can assess progress, and eventually move tremolo practice into "maintenance" mode, and begin the cycle again.

Other than the need for concentration and the necessity of feedback, the six rules given above are guidelines, not laws. For example, while deliberate practice is normally done alone, some endeavors simply require the presence of another person. Wrestlers and ballroom dancers can only go so far without practice partners. The partner provides the feedback that is essential to improving performance.

Deliberate practice can be applied to any skill or capacity that thrives

on practice. Activities like long distance running have been studied as subjects for deliberate practice. Clearly, compared to the musical example given above, running is not a highly skilled activity. Training for running, however, does vary greatly in skill, with some runners being much more successful than others in finding the fine line between training for maximum performance while avoiding overtraining and injury. The interesting point is that deliberate practice can be applied to something where the performance goal is to increase a capacity rather than a skill.

How long to practice, & when

Deliberate practice is tiring. Ericsson, in his study of high levels of expertise, found that experts often take a break after practicing for about an hour, and they rarely do more than about four hours of deliberate practice a day. Any more and exhaustion starts to set in. Ericsson found this to be true across a wide range of occupations: Musicians, athletes, chess players, writers. Expert's actions seem to say it is best to stop once concentration fails.

The important qualification is that we're talking about deliberate practice, not total time on task. A musician may play for ten hours a day, but they tend to do *deliberate* practice for no more than about four. The rest of the time may be spent on material that is already well-mastered, or in free improvisation, or in any number of ways. But the focus, concentration, and intense attention to feedback will not be the same.

Gradual increases in amount of deliberate practice over time are the norm, probably as the capacity to concentrate on the particular task develops. Being able to do four hours of intense practice a day is an achievement in itself. It comes with a price, of course. Four hours of deliberate practice can be exhausting, and experts tend both to sleep and to take naps more than non-experts.

Experts in tasks requiring intellectual skills most frequently practice in the morning, when capacity for complex cognitive effort is greatest. On the other hand, athletes tend to train in the afternoons or evenings, when perceptual-motor abilities are at their best.

Just practicing a lot is not a substitute for deliberate practice. It is possible to practice and not improve, and some kinds of practice are clearly better than others. Ericsson makes the controversial claim that

when a number of people do deliberate practice, all will learn about the same amount if they practice the same amount of time. Stated another way, the claims is that some people are not more talented than others; what makes perfect is not talent, but practice. This assertion will be examined below.

If you want to be the best, you'd better be ready for a long period of gradual improvement, because to achieve very high levels of accomplishment seems to require, in general, at least 10 years of pursuit.

Motivation

Deliberate practice is, in general, not fun. As mentioned above, it is often a commitment to focus on what the learner is worst at. That's why it is so hard, and why most people don't do it.

The motivation for doing deliberate practice is that in the long term it makes you better. Short-term rewards must often be set aside. When talent is even roughly equal, coaches and experts agree that the most important factor in eventual success is desire to succeed, the motivation that supports the learner through all the intense work of deliberately practicing.

It doesn't have to be grim, though. In order to ease motivation, stressing the likelihood of future rewards, inventing short term rewards, and embedding learning in enjoyable situations can all be productively used

Ultimately though, for the task to truly be mastered, the learner has to take a deep pleasure in its performance. In a Kenneth Cooper-directed study contrasting world-class and national-class male runners, it was found that the national-class runners actually trained more than the world-class runners. (Don't get the wrong impression that the world class runners did it all on talent; it appeared rather that the national-class runners were simply more likely to overtrain.) The most interesting finding relative to motivation was this: The world-class runners generally reported their primary motivation was that they loved to run. They reported that they would run whether they raced or not. The national-class runners, in contrast, reported themselves motivated much more by desired racing success. Their "love of running" rating was much lower. Deliberate practice is simply too hard to do if you don't at a deep level truly enjoy the process.

Natural ability
When talking about talent or natural ability, expertise researchers generally claim that, yes, some people are talented, but that what "talent" really is, is the person's natural predisposition (his or her attitude, emotions, motivation) toward doing deliberate practice. They claim there is little or no role for natural ability for a specific task, except insofar as the task requires an obvious physical characteristic such as height or bulk.

For example, Ericsson cites Polgar, who decided, with no *a priori* reason to think that his daughters would be especially talented, that as an educational experiment he would train them as chess players. His technique was early and focused training—deliberate practice. The three sisters went on to become first, second, and sixth ranked women in the world. The youngest daughter became the youngest grandmaster chess has yet seen.

Despite such compelling anecdotes, the author believes the claim that natural talent has little meaning is an artifact of the researcher's study designs. Typically, researchers have studied what distinguishes the best experts from their high-level peers. Why is someone the Symphony's First Violin, and someone else Second? What makes this player an NBA starter, and this other a back-up? But this is surely a skewed sort of sample. It doesn't begin with a representative cross-section of aspirants (high school freshman basketball players, for example, even though that is already a skewed sample). Rather, it begins after many years of winnowing and selection have taken place. Beginning with the highly talented and looking for variation *assumes* talent as a constant. This may be fine for distinguishing among high levels of expertise, but it doesn't justify the claim that talent doesn't count.

If "obvious" elements like height can be allowed as talent that does count, what principled way is there to filter out the slightly less obvious? Cardiovascular capacity and maximum oxygen uptake, for example? Reflex speed? Mix of fast-twitch and slow-twitch muscle fibers? Balance and coordination? For that matter, working memory capacity? It is a strained argument to say that the things that are easy to see can be allowed as important natural talent, but things that are harder to see or quantify can't.

Limits of deliberate practice

The amount of deliberate practice seems to be what separates the best experts from their peers. Deliberate practice is tremendously powerful, but it is not always enough.

- Tasks vary in the degree to which they can be broken into components, and in the degree of difficulty involved in integrating separately practiced components.
- The degree of control over practice conditions can vary greatly from task to task. It is easier for musicians and chess players to control the scheduling and the material of their practice than it is for surgeons.
- Repeatability is variable among tasks, especially when multiple learners are involved, or competition is significant. If the task requires interaction with a dynamic environment, repeatability decreases as well.
- Feedback also varies in its immediacy and its reliability. For example, experienced distance runners know that the most likely time to sustain an injury is when feeling great (because that's when overextension is most tempting).

Finally, there is the fun factor. Deliberate practice is described as being "fun-independent", something done regardless of pleasure or the lack thereof. But in Starkes et al's study of top athletes, things rated as most fun to do were also rated as most important for training. Some things critical for improvement are fun (if hard), even when they don't allow for a great deal of precise repetition and feedback. Basketball players scrimmage. Jazz musicians jam. Philosophers argue. These are all fun for the participants, necessary for improvement, require concentration, but each fails the criteria of deliberate practice.

Because amount of deliberate practice consistently seems to distinguish the best experts from their (marginally) less-accomplished peers, it is tempting to say that deliberate practice is all. However, this does not mean that other things are not important. Even something as trivial-appearing as "messing around" during practice of a sport or skill. If all of the best practitioners mess around at least enough, then that will not show up in the statistical analyses used to distinguish levels of expertise. As argued above, that it doesn't show up doesn't mean it is unnecessary.

Why doesn't everybody do it?
Deliberate practice may yield less impressive results in the short run, and it's hard and it often isn't fun. Whatever disagreement there may be about other aspects of natural talent, everyone agrees on the need for determination that is well above average. It's said that when Magic Johnson was a kid, he'd practice in weather so cold his basketball would *break.*

Indicators
Deliberate practice is indicated when learners want to achieve very high levels of proficiency, are willing to put a lot of effort into training, and expect to practice the skill(s) for a prolonged period of time—meaning continually and indefinitely. The skills most appropriate for deliberate practice are those whose perfection never ceases.

Counterindicators
Difficult-to-decompose task structures, high degrees of variation in task conditions or performance, difficulty of controlling practice circumstances, problematic feedback, and low repeatability all mitigate away from deliberate practice.

Common problems
Loss of motivation can occur, especially as a result of consistent focus on the weakest elements or performance, and an accompanying perception of slow progress. Having a range of objective, external performance benchmarks can sometimes ameliorate this.

Monitoring concentration during practice is an important skill, and being willing to stop when it is the right time takes discipline.

There is a natural tendency to want to perform, or to become satisfied with what has been accomplished. Paradoxically (since deliberate practice focuses on performance), the more the attention remains on learning goals, in contrast with performance goals, the more effective deliberate practice will be.

Related techniques
Learning versus Performance Goals
Automaticity
Overlearning
Feedback Sections
Goal Sections

Sequence - Hard Or Easy

References
Ericsson
Starkes et al

DON'T TAKE YOUR TIME: DECISIONS UNDER STRESS

Description
Under stress, focus of attention narrows, and decision-making strategies that are overly complex fail. In stressed situations there may be neither time nor attention to employ complex strategies. It makes sense, then, that people should not be trained to use a complex strategy if they won't be able to use it in the actual situation.

Heuristics that minimize demands on mental resources are much less vulnerable to stress than more analytic and time-consuming strategies, even though the latter may be more accurate. Because heuristics are simpler and more distilled by experience, even a narrowed focus can include more of them than it can something more complex. Second, automatic and overlearned responses are more likely to be fully integrated with heuristics, which both reduces the effects of time and other stressors on performance, and frees (heuristic-guided) attention for the areas where it is most likely to be valuable.

Train your people with decision-making tools they will be able to use in the situations they'll actually have to use them in.

How to do it
Don't train complex decision processes if these cannot be used on the real-world task. Your trainees will do worse than if you didn't train them at all. Instead, let them know what outcomes are expected, then give them the opportunity to practice in a variety of situations, with an increasingly realistic stress loading.

Practice situations should be set at the "right" tempo and stress levels. It is a mistake to put trainees in situations where they just can't keep up. It destroys confidence and leads to learning inappropriate adaptations. Slowing the training task down or reducing the situational stress may be called for, especially if there are important elements of the task or the task environment they need to become accustomed to. They should be allowed to learn these in an easier or slower (or both) setting than they will later

encounter in real life. However, caution should be exercised to avoid letting trainees practice and become comfortable doing the task slowly or in too easy an environment. Speed and stress should always be great enough that the trainees use the same decision strategies they will use in the criterion situation.

If there are prototypical situations they will encounter over and over, provide them with a repertoire of known, good decisions and the opportunity to practice these in a realistic range of situations. If this is not true, or if they will need to create the desired outcomes in a very wide range of circumstance, then insofar as possible, let them develop their own heuristics. As long as the trainees receive adequate feedback during training, their own heuristics will be more deep-seated, and therefore more reliable under intense stress, than imposed rules.

On the other hand, if a particular structure for decision-making must be used, finding mnemonics or heuristics that lead to the right set of criteria can ease the learning and recall tasks. In the U.S. military, for example, "METT-T" is the standard mnemonic for leaders in the field—Mission, Enemy, Terrain, Troops, and Time. Not a decision process, per se, but a quick way for commanders to make sure they have considered the most important relevant factors in their highly stressed field decision making.

If the task is decomposed for teaching, care should be taken that the divisions are as "natural" as possible with respect to to how the trainees will need to perform in the real world. Learning artificial components can lead the trainees to develop heuristics or decision approaches in training that are "good" for training but inadequate for real life.

Finally, let the trainees know that they need to practice monitoring their own decision processes. In order to make the best decisions they can under stress, they need to learn to watch themselves so that they use the right amount of time to decide (nether too much nor too little), that they don't fixate on their first idea, that they allow time for action once a decision is made, and so on. Let them know that self-management is crucial when under stress. A specific technique to foster this is having them articulate a detailed self-critique (focused specifically on their decision-making) after their

practice sessions. Specificity and searching for candidate cause-effect relations between their decision processes and the observed outcomes are key.

Indicators
Training in heuristic decision procedures is appropriate when the trainees will have to make decisions under stress or in a significantly limited amount of time.

Counterindicators
If out in the real world, the training graduate will not be under high levels of stress, it makes more sense to train them in use of more complex and accurate decision strategies.

Common problems
The point is to find the right balance between being certain the trainees can perform the task smoothly under stress if necessary, yet sacrificing accuracy and cool-headedness as little as possible. If you find trainees are not adequately accurate, increasing the structure of the decision process may be necessary, although joining this approach with others (as listed below) may be useful as well.

Related techniques
Automaticity
Simulation
Behavioral modeling
*Stress
- Stress - Full Information
- Stress - Graduated Training
- Stress - Phased Training
- Stress - Emotional Training
- Stress - How To Practice
- Overlearning

References
Driskell and Salas

ENACTIVE MASTERY

Description
Sometimes learning something new is intimidating. It can help to try to limit the amount of intimidation to improve the effectiveness of training. Enactive mastery is a way to increase self-efficacy.

How to do it
The aim is to ensure that fears are not realized while a task is accomplished. Even when a task is successfully completed, self-efficacy is lost if the learner is intimidated in the process. Enactive mastery is achieved by creating an atmosphere where trainees become comfortable while they perform training tasks.

Arrange it so that the learner knows in advance what they will be taught. Set goals that are attainable but hard so that progress is measurable and felt to be worthwhile. Let trainees do well for a while. Introduce challenges when they feel good. Wait until they can predict and manage threats or problems. Make sure they actively participate with the subject matter and experience success.

It makes sense to use this technique in conjunction with approaches such as contract theory and locus of control.

Indicators
This is a good, general approach for all types of training. It is especially useful for beginners encountering new fields.

Counterindicators
Enactive mastery may not be necessary for short, easy task training.

Common problems
Goals may not have been clearly understood and may need to be restated. It may be initimidating in itself for some trainees to admit to feeling initimidated. Techniques such as establishing an environment, and the sections on positive environment may prove helpful in overcoming this.

Related techniques
Attitude: Locus Of Control

Contract Theory
Establishing An Environment
Socialization

References

Latham
Gist 1986

ESTABLISH AN ENVIRONMENT FOR TRAINING

Description
A trainer can make his or her job a lot easier by establishing clear boundaries for when training is and is not happening. Training should be a definite and purposeful activity. In this way it becomes a habit that is taken seriously. A positive set-up is created which in turn leads to a positive mood which has been shown to be conducive to learning. Such a set up is aided by establishing a training environment.

How to do it
Make sure the physical environment signals the need to concentrate and work hard. The environment itself cannot produce good training habits, but it should not interfere with them. Always start training with the same simple procedure such as a group meeting, or a lap around the gym. Employ an end routine in the same way.

Breaks are thought to be important not just for refreshment, but also as a tool to end a training period which has become unproductive. Taking a break can help to avoid the association of training with unproductive activity and to help preserve the right atmosphere. Make sure any breaks are clearly signaled and of a set duration. There is a view that breaks should occur within the same physical boundaries as training. This ensures continuity and fewer lapses from a schedule. As a training routine becomes more established, trainees often find they can accomplish more and need fewer breaks.

Using this technique produces an environment which reinforces the habits learned in training. Other techniques should be used to make sure these are good habits. You might also want to encourage those being trained to create their own training environment when they practice without you.

Indicators
This approach to training is appropriate when training is long term, and/or intensive. It is also important whenever the trainer and trainee are new to each other. The training environment matters whether it is in a social context, a work setting, with a team, hands on training, or any other type. It can be used for instruction or

practice.

Counterindicators
When training is to be light and short or whenever a high level of concentration is not needed.

Common problems
People can develop bad training habits. A change to the training environment may be needed to prevent it continuing to reinforce these.

Related techniques
Mood
Making Training Seem Important
Lead-By-Example
Socialization
Shaping
Attitude, Expectations

References
Domjan & Burkhard

FEEDBACK—WITHHOLD IT

Description

As a general rule, it is good to give trainees feedback. However, it is sometimes beneficial to withhold feedback, so that the trainee can learn to use intrinsic cues, either from within himself or herself or from the environment.

How to do it

In some tasks, extrinsic feedback can be weak, ambiguous, or even misleading, and practitioners must be sensitive to intrinsic feedback to adjust and adapt their actions. When this is the case, it is useful to withhold feedback, forcing the trainees to rely on intrinsic cues about what they're doing and the consequences of what they have done.

To do this, feedback should be withheld on some, but not all, of the trials during a training session. A moderate level of competence should be present before feedback is withheld, so that trainees are ready to develop their reliance on intrinsic cues without too much error in selection or interpretation.

"Too much" is admittedly vague. The trainees should be allowed to make mistakes and learn from them ("if knowledge is power, then error is fuel"). On the other hand, it is not desirable to have the trainees learn wrong cues or wrong cue interpretations. The line must be found between enough feedback for guidance, but not so much as to stunt the trainees' learning to find and use the cues for themselves.

Since withholding feedback is done to push the trainee toward relying on intrinsic cues, the feedback withheld will mostly be action feedback (feedback concurrent with the person's actions). There may be cases when learning feedback (feedback that comes at task completion) should also be withheld. If the structure of the task includes repeated episodes, with the performance on each sensitive to the performance on the last, withholding learning feedback can encourage development of good judgement regarding quality of task (episode) performance.

Depending on the task and the trainees, it may be appropriate to tell them you are going to withhold feedback. this serves two purposes.

It prevents them feeling like they are suddenly or inexplicably being neglected. And, it lets them know they have a learning goal of increasing their sensitivity to intrinsic cues.

The feedback at issue is only the feedback from the trainer to the trainee. It is hard to think of circumstances where it would be a good idea to artificially delay or withhold environmental feedback that occurs naturally during task performance.

Indicators

Tasks for which the practitioner must monitor and judge his or her own progress and performance in the absence of reliable external feedback—tasks where workers are often far removed from supervisors or coworkers, for example—withholding feedback is indicated.

Counterindicators

If the nature of the task is such that the external cues are sufficiently strong, then withholding feedback may slow, rather than speed, the learning process. For example, if in task performance there is immediate and obvious feedback from the environment about whether the act worked or not, then the feedback the trainer is going to give is likely to be about how to perform the action, not what action to perform or what cues to attend to. When this is the case, withholding feedback may confuse the trainee, or may allow bad habits to become ingrained.

Common problems

Be very careful with when and to what degree feedback is withheld. Don't withhold feedback that would be difficult for the trainee to find on his or her own. When particular trainee actions if left uncommented would likely be misinterpreted, provide the needed feedback. While it's better if they learn for themselves, the trainer must be sensitive to the rate of learning and the potential for mislearning.

If the trainees are not picking up the intrinsic cues of the task even with the trainer's guidance and feedback, then they are not ready for feedback to be withheld.

Related techniques

Feedback—Delay
Advance and Back Off
*Things That Get You To Rely On Cues
Immediate Practice
Learn By Doing Only

References
Holding

FEEDBACK—PAUSES & DELAYS

Description
While feedback permeates training, there are times when it is good to pause after a training episode before giving feedback, or simply to delay giving the feedback during the training performance.

Pauses and delays are useful to the extent that they make it easier for the trainee to absorb and assimilate the feedback. Sometimes it takes time to understand and integrate feedback. Pausing provides this kind of breathing room. And sometimes it is better for the trainee to form his or her own opinion about what has happened before hearing the trainer's view. Delaying supports this.

How to do it
Pauses and delays are cousins, and both useful to allow trainees to process feedback information, whether to guide current performance or to plan their next action. Pauses are applied to learning feedback, and delays to action feedback (see Feedback).

A pause, correctly applied, comes after post-training episode feedback. The trainees perform the task, receive feedback, an appropriately-timed pause is given, and they are sent on to next practice trial. The pause should not be between the end of the training episode and the receipt of feedback. Pausing then doesn't really help the trainees, and it can be interpreted as anger or punishment.

If the task is complex, going over trainees' performance before providing feedback can clarify the relationship between actions and observed results. In addition, it provides an opportunity to highlight the most important factors. This will make understanding and applying the feedback more straightforward for the trainees. It may also break up any tendency trainees may have to "lock on" to a particular interpretation of their actions, to the possible exclusion of the trainer's presumably more clear-eyed appraisal.

If the task is such that delayed feedback doesn't become instantly stale, either because the action of interest has been superseded by a dozen others, or because the stress level in the task makes the mental effort of associating delayed feedback with the right action

too great, then allowing a delay can let the trainee practice self-generating feedback. This will almost always be a desirable training goal. The length of the wait will depend on the trainer's judgement about both the task and the trainee, but the point is to wait just long enough that the trainee has formed his or her own opinion of what is going on. Then when they receive the feedback they have something vivid, something of their own, to compare it with. Not only does this serve immediate task improvement, but the trainer's feedback now serves the dual purpose of illuminating both the task and the trainee's growing skill at self-assessment and self-correction.

All of the feedback discussed above is that from trainer to trainee. Artificially delaying environmental feedback that would otherwise occur naturally during task performance is not likely to be helpful, unless during the early stages of training the trainees need time to prepare to receive and use the feedback.

Pauses and delays can help trainees use feedback smartly. "Smartly" doesn't necessarily mean consciously, since substantial learning takes place without conscious awareness. But having an extra moment to process self-generated feedback during task performance, or to let the trainer's feedback sink in, can accelerate learning.

Indicators

Pausing or delaying feedback is useful when the trainee is likely to be able to use the pause to formulate and test his or her own hypotheses about actions and results. It may also be useful in tasks where the performer has a chance to correct or compensate for errors made earlier in task performance.

If a substantial amount of internal control and self-optimization is required for the task (as is often the case in athletics), pauses and delays can allow the trainees to experiment more freely to find their own balance. The risk is in letting potential bad habits take root and grow.

Counterindicators

Don't get carried away. Usually, feedback should either be immediate (action feedback) or in close proximity to completion of a training session (learning feedback). If because of the nature of the task it is difficult for trainees to see the relationships between their actions

and the results, delaying or pausing feedback is probably not going to be a good idea.

Common problems

Trainees accustomed to immediate feedback can interpret it's delay as disapproval. Warning the trainees beforehand of the intention to delay can ameliorate this.

Allowing the trainees to begin another task before providing feedback on the last and allowing them to digest it can dilute the effect, even to the point of making the feedback useless, or worse.

Related techniques

Feedback—Withhold

Also see:

Reinforcement

Rewards & Punishment

References

Holding

GAMES AND SIMULATIONS

Description

Games and simulations are ways of letting people practice the task they are training for without actually doing it. The information below is about how to use games and simulations, but not how to design (or in some cases, afford) them.

How to do it

There are many types of simulations. The point of a simulation is to provide an acceptably realistic task environment when the actual environment is not available or too dangerous for trainees to practice in. The key thing is that the actions taken by the trainees do not have the effect on the world that they would in real life.

A simulation is elaborate practice. It requires preparation, planning, and debriefing, especially when it is complex. One view holds that it is best to start out with lectures and examples. These can be followed with demonstrations and games or simple simulations. It very much depends on the content of the task. For some tasks a very great deal of preparation is necessary before a simulation can be productively (or safely) used.

A game can be a simulation or it can be an activity where the skills needed are used, but not in the task itself or even in a situation that simulates the actual task.

Selection of the game or simulation is important. Ensure it contains enough feedback, pointers and instruction to make your assistance minimal. Let the simulation or game run. Be on hand to answer questions or to handle emergencies depending on the nature of the training. Afterwards, apply feedback, reinforcement, coaching, and practice with regard to specific task components. Just as with practices, do not rely on the simulation to do it all for you. The results or built-in tests may themselves show whether or not tasks have been learned. If not, supplementary tests can be provided to ensure relevant knowledge has been gained.

Indicators

If you have a dangerous task that you want people to be able to

practice without danger, you would be well served by using a simulation. A simulation is also useful if the task is costly or does not naturally occur often enough to provide consistent practice.

Games may be helpful in making dull tasks more fun. They can also encourage people to perform well. Simulations are helpful precursors to on-the-job training.

Counterindicators
Simulations can be expensive. They can also be used beyond the point where on-the-job training should be started.

Common problems
Using a simulation as a beginning training tool will make training too hard. The learner may miss the underlying causes, meanings and relationships. Also, trying to learn while being highly active can cause problems because no time is allowed for reflection. Remember that simulations in particular are designed for the application and support of learned information, not for basic learning itself.

The simulation should get the important cues right as far as safely possible. It should not be possible to learn to be effective at the simulation without corresponding growth of skill at the real task. Said another way, it shouldn't be possible to "beat" the simulation using any skills specific to the simulation.

Related techniques
Computer Aided Instruction
Deliberate Practice
Stress - How To Practice

References
Tannenbaum and Yukl
Thornton and Cleveland

GROUPS: COOPERATIVE LEARNING

Description
This technique applies to learning as a cooperative process. This is encouraged by giving the whole group an equal reward based on its performance or improvement as whole. A reward structure for groups is used whether or not members will be doing the task together.

How to do it
Divide trainees into groups. This can be done on a basis of similar ability levels if task performance alone is a priority, but greater cooperation will be learned if group members are of mixed ability. Socialization and buddy techniques can help in group selection. Competition is avoided if groups are assigned different tasks.

Ensure each group is clear about its task expectations and any time constraints. Explain the reward criteria. These should be based on task component skills and completion, improvement on any previous efforts, and overall performance. In addition, good training skills and attributes should also be rewarded such as use of feedback and positive attitudes.

Monitor the groups while they work on the task and as they use their learning and training skills. Be on hand to answer questions. As in paired post-training, it may help to end with feedback from all the groups about their experiences. Give rewards to each group individually, but in a consistent fashion.

Research shows that cooperative group training can be more effective for most tasks than competition or individualization. Rewarding in a group structure aims to help people learn from each other. It also helps them learn to purposefully train each other. There is a view, too, that group rewards are especially helpful to slower trainees.

With any group rewards, some observers believe it is still important to retain some individual accountability. This is thought to prevent those of higher ability not trying and those of lesser ability from failing to contribute. Individual accountability could occur more in terms of performance reviews and advancement than explicit reward

structures.

It is best to strike a balance between reward structures for groups and individual training. This ensures trainees receive individual attention and customized training.

Indicators
This approach is considered useful for most group training situations. It is especially useful when a high degree of cooperation is needed for task performance, or when trainees are learning how to train. Similarly, reward structures for groups can be used if competition would hinder task learning, for example leaving slower trainees behind, or encouraging an attitude that success depends on others failing. Rewarding groups can also aid socialization if you are introducing new members to the larger group.

Counterindicators
Very large groups and numbers of groups are hard to monitor. Some tasks to be completed alone are learned more efficiently alone. A high degree of preparation and equipment is sometimes needed. Group rewards are not useful when a task requires customized training.

Common problems
Group training can fail if group norms dictate that some or all of the trainees not do their best. Insufficient monitoring and reward can also encourage goof-off and/or demoralization.

Related techniques
Teams - General methods
Teams - Cooperative controversy
Paired post-training

References
Baldwin and Magjuka
Goldsmith and Krager
Keinan and Friedland

INTERACTIVE IMAGERY

Description

Remembering images instead of words can make recall easier. When you have to remember a list of items, it is a good idea to have them trigger each other. That way, you only have half (or less) the amount to remember.

How to do it

If you are trying to memorize a list of nouns, do it in pairs and create mental images showing the items together in an interactive way. They will trigger each other.

So maybe you have to buy a rabbit, a xylophone and some matches at the store. To remember this list, picture a rabbit playing the xylophone with some matches (on the clerks head, if you want). This will make it easier to remember all of the items because you will only have to remember one thing. Also, there will be an interesting image to remember, so it will be easier to remember (maybe).

This works most easily with nouns - things of which you can form images.

Related techniques

Those in these sections and the sections about complex memory tricks.

References

Kyllonen & Alluisi

LEARN BY DOING ONLY

Description
Do not instruct. Simply allow the person to progress, and give them challenges until they reach a sufficient level that training can be terminated.

How to do it
Tell the trainee to start doing it.

It helps if they set goals, especially if it is an individual activity. Goals provide feedback on progress to the person, as well as opportunites for improvement. It is important to keep motivation high, by having fun doing it and seeing progress.

Learners should be able to:
1. Model their behavior on others who are already competent at the task.
2. Participate or compete with those with more experience, so that mistakes are made visible and/or admonished.

To be effective, there must be substantial feedback intrinsic to the task and the environment must be stable and appropriate.

Indicators
This technique is appropriate when through minimally supervised practice trainees can achieve an adequate level of competence.

Counterindicators
The easier it is to get feedback from the environment, the better this technique will work. The technique is inappropriate if bad habits are easy to develop.

Common problems
If it is easy to get frustrated, or there is significant risk of injury, this is inadvisable.

Related techniques
Limit Introduction
Learn By Mucking About
Feedback - Delay It

Feedback - Withhold It
Path Goal Theory

References
Ericsson

LET TRAINEE BECOME MASTER

Description
Initially trainees do best with a lot of external support in the form of motivation, guidance, teaching and feedback. Good training develops self-motivation, reliance, direction, and practice ability. Eventually students are ready to direct their own training, to become their own masters. Support or competition is then requested by trainees only as it is felt to be needed.

How to do it
Gradually decrease environmental support, and start to implement training that stresses good practice skills (see guided practice alone), self monitoring, evaluation and feedback. Equally important are self regulation and organization, and the ability to identify progress and errors.

The goal is to reach a point where learning is designed and controled by the trainee. Once trainees are highly motivated, familiar with and very comfortable using training techniques independently, they are ready to be their own masters. Learners will then take advantage of competition, coaching and social interaction as needed. Training requested is likely to be improved because salience of feedback should increase along with productivity and amount of practice if trainees were well prepared. Increased strength of motivation, confidence, and self efficacy may also follow.

Work on building a strong basis in fundamentals since this will be essential for the student to be able to self correct. Guided practice alone can be followed with short sessions or simple tasks where the student is master. This may help to build confidence, ensure that mistakes are not practiced, and allow time for post-session feedback. Be prepared to step in on request, if mistakes result, or if learning slows down considerably. More practice and observer feedback may be needed.

Trainee as master is based on research which shows that people learn learn best if they have opportunities for problem solving, analogy making, extended inferencing, interpretaton, and for working in unfamiliar situations requiring transfer. Deep understanding of how

things work is best achieved when people are totally involved and solve problems themselves. This does not occur if a trainer's presence distracts from total involvement or if a trainer always provides answers.

Indicators
Student as master becomes applicable during long term training which calls for large improvements in ability. It is not necessary that the trainer and trainee have spent a long time together. Both high trainee motivation and good mastery of basics signal the time for practice alone followed by student as master.

Counterindicators
Some tasks require a trainer or opponent to provide expert and/or audience feedback. This is true especially of performance activities such as dance. Trainees of a young age may also require external support even after they reach an expert level.

Common problems
The trainer has no right to observe once supervised training has been completed, unless invited to do so. However, potential problems are lack of motivation, practicing mistakes, and inefficient practice. If you notice that trainees deviate from good training habits, you may want to work on the areas involved.

Related techniques
Deliberate practice
Practice alone

References
Glasser
Simonton

LIMIT INTRODUCTORY INSTRUCTION—PRACTICE INSTEAD

Description
This is a way of training someone to do a procedural skill. When learning a procedure, it is good to have someone explain it to you, but it is necessary to practice actually doing it yourself. The suggestion here is that you limit the introduction students get through lecture, books, etc., instead giving them something brief, and then let them actually do the thing.

How to do it
Limit the amount of introductory instruction, and let them do it. Often times you use instruction (as opposed to practice) as an introduction to the material. The suggestion is they will learn it as declarative knowledge if you do this, whereas if the introduction is brief, and then you let them begin practice, they will learn it as a procedure, which is good if what you want them to remember is a procedure.

Give them feedback during the practice so that they get it right. Immediately correct errors. You are allowing them to do things any way they want, so you have to be careful that they do them right.

But, if you start out by giving a lot of negative feedback, then they are going to learn that the task it hard, they are not good at it, and that it is not enjoyable. So, don't point out every mistake at first, and emphasize positive feedback.

Indicators
Any time you are trying to teach a procedure.

Counterindicators
This is not suitable for a complex cognitive tasks, or tasks where there is very little feedback intrinsic to the task.

Common problems
By overly limiting introduction the student may learn improper form or habits.

Related techniques

Learn By Mucking About
Learn By Doing Only
Immediate Practice
Adaptive Training
Stress - Full Information

References
Glasser and Bassok

MAKING TRAINING SEEM IMPORTANT (MANAGING TRAINING IN ORGANIZATIONS)

Description
Sometimes trainees are motivated, sometimes they don't feel like trying that hard, and sometimes they think you have nothing to offer and are resentful at just being in training at all. This section suggests different ways to convince trainees that the training they are going to receive is useful and worth effort, and that they should try to make use of it on the job and learn something.

How to do it
There are a few things you can do.

1. Be a supportive supervisor

Cohen (1990) found that if you have supportive supervisors, you enter training believing it will work. They can show support by discussing the training with the employee, establishing goals, providing release time to prepare, and encouraging the employee. Also from this study, it seems that those who set goals entered with higher motivation to learn, but based on the nature of the study, it is impossible to determine causality.

2. Follow-up / assessment

Baldwin and Magjuka (1991) found that if trainees enter training expecting a follow up activity or assessment, they will report stronger intentions to transfer what they were going to learn back to their jobs.

3. Long term importance of training

A recurrent theme is that how you treat one training program will effect other ones. If employees get the impression that the managers and trainers care, then they will try to learn. If they have the impression that 'training' means 'goof off and learn nothing' then they won't. Try to set the right atmosphere in the first place.

Indicators
This section is intended for managers who have employees to be trained.

If you get the feeling that your people don't have any respect for training, or if you think they could be getting more out of training, then you want to use the techniques above.

Counterindicators
If there the problem is out of your control, there may be little you can do.

Common problems
It can be easy for trainers to act like bosses at times. This may be hard to avoid, especially in situations where trainees are likely to treat you like their boss. Use socialization and positive environment techniques to lessen these effects.

Related techniques
Goals - Learning Vs Performance
Socialization
Training Different Ages
Contract Theory
Choices About Training
Lead By Example - Attitude
Establish Environment

References
Tannenbaum and Yukl
Cohen
Baldwin and Magjuka
Noe

MATCH THE COMPLEXITY OF INSTRUCTION AND PRACTICE

Description
Design training so that trainees practice what you teach them, by making sure that the practice is appropriate for the instruction you have given and vice versa. If the instruction is complete, let them practice the complete task. If the instruction is simple, make the practice simple. What they learn in instruction, they should practice.

How to do it
The important thing is to make sure that practice is designed so that they will use what you teach them. If the instruction and practice are not matched, the trainees will not be able to make use of what they learn during instruction, and therefore it will not be learned as well.

Indicators
The greater the distance between instruction and practice, measured in either time or location, the more important this is.

Counterindicators
If instruction and practice are concurrent, this tends to solve itself. If there is a practice that also requires a distinct explanatory component, this may not be relevant.

Common problems
If instruction and practice are mismatched, lower efficacy will result.

Related techniques
Immediate practice
Don't take your time
Operationalize Definitional Concepts

References
Caplan and Schooler

MENTAL SIMULATION

Description

When there is restricted opportunity to practice something, an alternate technique is to simulate practice mentally. If you do this realistically, research shows that it produces measureable learning in many skills.

How to do it

The practicer imagines the situation as accurately as possible, trying to include all of the important details. Then, he or she imagines as vividly as possible the feeling of doing the task exactly right. This is repeated, as would be done in a real practice session.

Indicators

Mental simulation improvements are usually made in "motor programming," that is, in complex physical action.

Counterindicators

Mental simulation requires intense concentration, often even more than is necessary in actual task performance. As a result, it is tiring, and not everyone can do it effectively.

Common problems

Inattention and inaccuracy are the most common problems.

Related techniques

Deliberate practice

References

Lynch
Harding

MENTORS

Description
A mentor is someone who has experience in the task or the organization the trainee is entering. Having a mentor can be very helpful for people, and this section describes how mentor relationships can be created by trainers or managers, how mentors are most effective, and how to train mentors.

There is a large range in what can be called a mentor. A mentor can just be a high ranking friend who gives you a little support when you need it, or it could be someone who is intimately involved in your career choices. Also, there is a lot of range in "assigning mentors." This could be anything from posting assignments on a bulletin board for every member of the organizations to a friendly word of encouragement about someone's mentor relationship.

How to do it
The best mentorships are usually the ones that develop on their own, not the assigned ones. Tannenbaum and Yukl say that the best thing is when mentor relationships occur naturally, but this doesn't always happen, and sometimes they are assigned instead. When this happens, though, there is the possibility of conflict and lack of commitment by the mentor - unless assignments and mentor training are done carefully. If you assign a mentor from whom the junior person learns to avoid hard work and to hate it, you are going to get a poorly socialized protege.

Zey (1988) recommends more use of mentors for difficult adjustments, such as to a new job, assignment, or country. Noe (1988a) and Kram (1985) found the same thing, which is that mentors serve two functions - one is psychosocial and includes acceptance, encouragement, coaching, counseling. The other is career oriented, and includes sponsorship, protection, challenging assignments, exposure and visibility. Noe found that people with assigned mentors get the psychosocial but not the career benefits.

Tannenbaum and Yukl say that instead of putting effort into making these assignments, or at least along with it that effort, effort should be put into improving the effectiveness of the mentors. As far as how

to train them, they identify six issues without actually making recommendations with respect to how to train them:

- How to identify an appropriate protege.
- Phases of mentorship and when to let go.
- How to coach without being overbearing.
- Rewards of being a mentor.
- How to reinforce company goals and values.
- How to work with a protege who is different from you (e.g., age, race, and/or gender).

Female managers tend to encounter stereotypes, which causes limited contact with potential mentors, and stereotypical attitudes toward the women by potential mentors, tokenism, gender differences in socialization practices, norms about cross-gender interactions/relationships, and differences in the acquisition and use of power. Successful mentoring can ameliorate some of these problems.

If you assign everyone a mentor, the people who are the mentors are going to be doing a lot of mentoring. The may thinking of the person they are mentoring as special and just think of them as one in a string of many people that they do the same thing for, and therefore they probably won't do a very inspired job.

Sometimes, training someone to be a mentor might be a bad idea. Effective mentoring is such a subtle skill that some people may be better off just doing it the way they know how. If they try to follow some set of rules or whatever you teach them, they may just become artificial.

Related techniques
Socialization
Lead By Example - Behavior
Lead By Example - Attitude
Behavioral Modeling
Advance And Back Off
Paired Post-Training
Don't Take Your Time - Heuristics

References

Racicot and Hall
Tannenbaum and Yukl

METHOD OF ELABORATION

Description

This is a way of making basically meaningless information memorable, by assigning meaning to it arbitrarily.

How to do it

Make up an interesting sentence that includes what you want to remember (not necessarily in an informative way). For example, "the car salesman returned the first car" is a way to remember that the command "car" in the computer programming language Lisp returns to the first item.

You can make up pretty complex things using the method of elaboration. The problem is that you probably want to remember these things for a while, and the phrase "the car salesman returned the first car," while more interesting than the plain information that the car command returns the first item, is still pretty boring. If you have no context to understand it in, and nothing to trigger that sentence, it is still going to be hard to remember the command. You want to make the things as easy as possible to trigger.

Indicators

This is useful when you have meaningless, low meaning, or arbitrary information to remember. The whole point is to assign meaning to make things memorable, so it is not so useful if there is already meaning there for you to remember.

Since each instance of this technique is different, it can be used for long term memorization.

Related techniques

Those in these sections and the sections about complex memory tricks.

References

Kyllonen & Alluisi

THE METHOD OF LOCI

Description
This is a technique for memorization. If you have a list of things to remember, you can associate each one with a different point on a well-remembered walk, and then as you go through the walk mentally, the things you want to remember will come to you.

How to do it
The first step is to memorize the walk.

Choose a set of landmarks that you always use, so that you don't "walk by an idea" without noticing. Memorize them thoroughly.

Then, take each thing that you want to remember, and try to form a mental association between it and the next landmark.

The most effective associations may be images. If you are trying to remember bread, imagine a loaf of bread at your first landmark. If the idea is more complex, you may be able to come up with an image anyway (use lions killing slower gazelles for natural selection, for example).

When you are ready to remember them, go along the walk mentally and see what ideas you come to.

The Pegword Method is a variation on the method of loci. Memorize a set list of objects (e.g., bun, shoe, tree) to be your "pegwords." Use the objects that you have memorized just like you use the landmarks on the walk: Associate the things to remember with the pegwords by forming mental images. Then, when you are at the store, think of the pegwords, and you will remember what to buy. For example when you think of bun, you will know that you have to buy carrots because you have an image of a hot dog bun with a carrot in it.

You can use other variations if you want, like the steps of getting ready for bed (brush teeth, take out contacts, turn off lights etc.)

Indicators
This is not as much for memorizing an unordered body of facts as for recalling lists of items or ideas. Despite what we said above, the

ideas don't have to be simple - the Greeks used this technique to remember the points they wanted to make in speeches, and the points were undoubtedly complicated.

This can be used to remember ordered lists or sequences of actions. You could associate each landmark with one of the steps of making sure an airplane is ready for takeoff, for example.

This can be used to memorize things that you only need to know once, such as a shopping list, and that is what it is intended for.

References

Kyllonen & Alluisi

MOLD MENTAL MODELS WITH QUESTIONS

Description
This method aims to teach complicated information through careful selection and timing of questions. Questions requiring less information are asked at first, simplifying things. Questions become progressively harder, in such a way that the learner's mental model grows into the desired form.

How to do it
The instructional task is to design the early mental models so that they can be transformed into the more advanced ones with minimum adjustment. The means to this is through explanation and questions that will foster mental models in such a way that they can be transformed.

Choose problems wisely. Questions that trigger a change of mental model should be carefully selected - they should be prototypical of the new approach, but also, they should be just beyond the trainees grasp. They should not be full of distracting cues - it should be clear both that something new has been introduced and what it is.

Using multiple learning strategies appears to be beneficial. Provision of opportunities for (for example) open ended explorations, information gathering, problem solving practice, demonstrations, and so on can support this approach.

Related techniques
Those in these sections and the sections about complex memory tricks.

References
Glasser and Bassok

NETWORKING

Description

Thinking and consciously makings sense of information when reading or attending a lecture can improve learning. Networking is another method to apply to this.

How to do it

The method is to encourage the learner to think about how different parts of the information fit together, how it all makes sense. Specifically, the learner is to construct a network in which information elements are explicitly linked, and in which the nature and content of each link is consciously considered.

Outlining is a related technique. The differences between the two are instructive. The basic mode in outlining is to group and differentiate, and then to sequence. Grouping and differentiation tends to rely on attributes - things are similar because they have similar characteristics. Outlining tends to be heirarchical, with less emphasis given to the interconnections among the diverse sections.

Networking, by contrast, emphasizes the interconnections, and is especially suited to domains where grouping by attribute is misleading and the underlying causal connections are a critical element of the subject matter.

Related techniques

Those in these sections and the sections about simple memory tricks.

References

Kyllonen & Alluisi

OPERATIONALIZE DEFINITIONAL CONCEPTS

Description

Complex definitional concepts, such as are taught in science and engineering, can be difficult to learn. Operationalizing the concepts adds both understanding and retention.

How it works

Frederick Reif developed a sequence of four steps for teaching complex definitional concepts:

1. Formulate a clear definition of the concept and accompany it by an explicit procedure specifying how this concept can be interpreted in any particular instance.
2. Let students practice applying this definitional procedure to interpret the concept in a variety of special cases.
3. Let students use their explicit knowledge about the concept to confront situations that are error-prone, either because of intrinsic difficulty or because of confusion with prior knowledge. In each case, ask them to detect mistakes of concept interpretation, diagnose the likely reasons for them, and correct them.
4. Guide students to summarize and organize their accumulating case-specific knowledge so as to acquire a useful repertoire thereof—and then encourage students to use their case-specific knowledge in familiar situations.

A key element of this approach is having the learners construct and articulate explanations, notably in steps 3 and 4.

Indicators

Any field in which definitional concepts are a critical element in problem-solving.

Counterindicators

Domains where knowledge is empirical or procedural.

Common problems

Students may resist offering explanations that might reveal lack of knowledge or misunderstanding. A safe learning environment is critical.

Related techniques
Self-explanation
How to learn complex information

References
Reif & Allen (1992)

OVERLEARNING

Description

Overlearning happens when you keep training something that the person already knows how to do, until it is totally ingrained. This means it is easier to do and attention is freed, at the cost of being less flexible.

Memory seems to be based on cues eliciting memories, and memories eliciting each other. Practicing a task after you already know how to do it, even if performance does not improve, will still lead to stronger and stronger associations between the different memories used in the task, and between the external cues and the memories they elicit (which lead to behavior). Thus, the more you practice it, the more strongly the cue will elicit the behavior, and in a sequence, the more strongly each behavior will elicit the next - what is called a strong memory.

Overlearning simplifies complex tasks by automating complex responses. An overlearned task can still be done under conditions that do not allow full concentration (stress). Overlearning also increases the sense of control, predictability, and confidence.

The problem is that overlearning decreases flexibility - both in that trainees will not adjust the way they do the task based on the environment, and that they won't learn from what they are doing. When something is overlearned, it is unlikely that the trainee is going to learn anything new about it - they are going to continue to do the task the way they overlearned it.

How to do it

Teach them whatever is to be overlearned. Then have them practice more even after they can do it. They don't necessarily have to get better at it to be advancing if the goal is to overlearn.

If possible, avoid overlearning in a non-criterion situation, or training in ways that will elicit different reactions in the criterion situation than in training. These will lead to poor training, and in fact can impede performance.

One important factor for stress is confidence. If you can just say "I know this is what I am supposed to do," you will be a lot more confident in doing it, and in deciding to do it. This is an advantage of overlearning in contrast with consciously understanding the situation. If you understand the situation, you may be full of doubt and conflicting responses. With overlearning, you just do it. Of course, it may be that the overlearned response is inappropriate, in which case training overlearning would be a mistake.

Don't attempt to develop overlearning if there are two competing responses triggered by the same stimulus. Overlearning competing responses raises the possibility of choosing the wrong one, or to freeze because two dominant responses are selected at the same time.

Actually teach variation and flexibility. People can learn to look for cues and make calculations as part of an overlearned behavior, if necessary, although if flexibility is needed overlearning is probably not a desirable approach unless very high levels of stress are part of the task.

For generalization to occur, make sure the task is practiced in different situations, so that the practice environment does not come to be overly-associated with the behaviors. Said another way, the behaviors should still be elicited in the absence of the training environment.

Indicators

Overlearning is most useful in tasks that always require the same response, reactions that should always occur, whatever the stress, distraction, or environment.

Counterindicators

Only overlearn things that are easy to identify. If there are competing responses triggered by the same cue, or if a cue is misidentified, trainees may not adjust their behavior appropriately or know what to do.

The overlearned response should be universally adaptive. A response that has to be changed as the event progresses should not be overlearned, nor should responses that are only applicable in special

circumstances.

Common problems
If you don't get it right, the trainees will overlearn the wrong behavior.

Boredom, fatigue, and sloppiness often arise. Avoid fatigue and boredom while practicing, because they can also come to be associated with the the task.

Related techniques
Automaticity
Shaping

References
Keinan and Friedland
Orasanu and Backer

PAIRED POST-TRAINING

Description
Trainees use learned training skills on each other when training is finished. They are given an opportunity to observe objectively instead of subjectively when a skill is being used. It's been found that paired post-training helps ensure good training behaviors are maintained and transferred to actual task performance.

How to do it
After finishing training, pair up the trainees. Pairing can be especially helpful when trainees are about to enter the work environment. Give some attention to pairing from this viewpoint. It can also be considered an aid to socialization.

Tell the trainees to monitor each other and to give each other tips, feedback and reinforcement. In this way, training habits become better established, and learning opportunities are provided for the trainees that they might otherwise miss. In a sense, you let them train each other. By alowing them to practice together without supervision they will also gain supervision skills. It makes sense, though, to provide final monitoring of tasks assigned to pairs. This helps to prevent bad habits and misunderstandings being passed from one partner to the other. For this reason, too, keep paired training sessions short to begin with. Let pairs compare results with other partnerships. It may help to end with feedback from the whole group about each session of paired post-training.

Whenever trainees are left to practice unsupervised, pairing can be used in the same way. This will lay the ground for more skilled and directed paired post-training. In some cases, however, it is probably more helpful to emphasize practice alone as a post-training approach (see counterindicators).

Indicators
This technique is useful after training when the trainee enters the task environment. It will help to insure that skills transfer takes place, and that the trainee continues to learn on the job. Use paired post-training when the job involves partnership of any kind. It is also useful in order to ease socialization and to help job entrants feel

comfortable asking for help and advice.

Counterindicators
If training has involved a great deal of pairing, but the actual skills are meant to be done alone, practice alone will be a better post-training technique. The same may be true when the task involves a high degree of concentration. However, paired post-training may still be useful in these cases when trainees have difficulty interpreting feedback without help.

Common problems
Bad habits and misinformation can be catching. Final monitoring and short initial sessions should be in place. Personality clashes, too, can make paired post-training unsuccessful. It is important to form post-training pairs with care. This will help to avoid pairing partners when one does not feel the other is credible.

The idea of paired training itself may not seem credible to trainees. Using the technique in training itself prepares the ground. Use related techniques to overcome resistance to socialization. Assign specific tasks to aid monitoring and feedback.

Pairs will vary in the time taken to accomplish assignments. Have further tasks ready for those who finish quickly.

Related techniques
Socialization
Feedback - Action Vs Learning
Feedback - Delay It
Feedback - Withhold It
Practice Alone (An alternative approach)
Advance And Back Off
Behavioral Modeling
Lead By Example - Behavior
Lead By Example - Atttitude
Mentors (An alternative approach)

References
Noe et al
Tannenbaum and Yukl

PATH-GOAL THEORY (FOR LEADERSHIP)

Description
A trainer motivates by defining goals, removing obstacles to attaining them, and rewarding their attainment. A good relationship is created between trainer and trainees when a clear path to their goal and its rewards can be seen.

How to do it
Neider and Schriensheim (1988) present three stages.

1. Precursor: Job analysis, compensation analysis, employee selection, orientation training.
2. Maintenance: Career pathing, goal seting, contingent reward and punishment, "individualised consideration."
3. Reassessment/monitoring: Performance feedback, problem solving, and reassessment of subordinate needs.

Simplified, they suggest that managers help the learner to set goals, remove obstacles (as far as is appropriate), let them know that they will be rewarded if they acomplish the goals, then reward them.

Indicators
A long-term relationship with the trainee, and time and skill to provide the guidance.

Counterindicators
This method requires high levels of supervision and long term follow-through. The leader needs to be able to control things like obstacles and rewards.

Common problems
Dilbertian management, especially a mismatch between the trainer and the trainee on skills assessment, goal setting, or performance evaluation.

Related techniques
Contract theory
Making training seem important

References
Racicot and Hall

PHYSICAL GUIDANCE

Description
When you want a person to learn to do a physical task in a certain way, a good approach can be to guide their movements. In this way, the trainee learns what it feels like to do it right.

How to do it
There are two approaches - forced response and restriction. Restriction is when you only allow the trainee to make the correct movements. Forced response is when, for example, you hold their arm and move it the way it needs to be moved. These methods make it clear which physical movements and positions are needed. Restriction is generally preferable, but harder to do. It calls for close supervision, constant repetition, and flexibility when the approach fails. Forced response can be a support approach to restriction since it will sometimes be the fastest way to help a trainee understand what's required. Prior demonstration is very important to both methods.

An ideal use of physical guidance is to set up initial positions. Once in the correct position, a trainee can often perform the skill being taught without further use of the technique.

Allow variation from ideal movements. This will create feedback showing when a movement is wrong, and also provide contrast which will help show which movement or position is right. Support the set of movements required with an explanation and description. This will help trainees to correct their form objectively when confusion arises during the movements themselves.

Always follow physical guidance with practice alone and monitoring. This allows the trainees to work from feedback and ensures mistakes are picked up.

Indicators
This technique is used in training physical movements. It is especially useful when a trainee fails to master a skill after repeated feedback.

Counterindicators
In some situations, physical guidance will take more effort than explaining and repeated demonstrations. In large groups in particular, this kind of one-to-one guidance may not be feasible.

If trainees resist when you guide them, they may learn to do the action incorrectly. Their independent movements will tend to revert to the position you were guiding away from. In this case physical guidance is inappropriate.

Common problems
Some trainees will resist. Explanation and demonstration may prove better techniques in these cases. However, restriction technique alone may be sufficient.

In large groups, alternative training techniques may need to be used to keep other trainees occupied while physical guidance is being used on a one-to-one basis.

Related techniques
Limit Introduction
Learn By Doing Only
Immediate Practice
Automaticity
Feedback Sections
Behavioral Modeling

References
Holding

PLANNED CUES FOR MEMORY

Description
If you want to remember something at a certain time or in a certain place, you can form an association between the thing you want to remember and something you are going to do or encounter at either that time or place.

How to do it
If you want to remember something at a certain place, form a mental image that will remind you of what you want to remember at that place. For example, when you get home, remember to call the doctor, so you imagine the doctor on your doorstep.

Make it specific. Not "have lunch," but "open the refrigerator door." Lunch is not really a specific cue, whereas the fridge door is.

This technique works best if there is some cue in the world that will trigger the memory. If you have to remember something at a certain time, find something that will be happening at that time to use as a cue. The more certain it is that you will notice the cue, the better the likelihood that the memory will be triggered.

This technique is effective for near-term recall, but there is no research suggesting it for long-term memorization.

Related techniques
Those in these sections and the sections about complex memory tricks.

References
Kyllonen & Alluisi

PQ4R

Description

PQ4R stands for Preview, Question, Read, Reflect, Recite, Review. This is a standard technique to encourage thorough understanding of textual material.

How to do it

The method is as it sounds: The learner first previews and generates questions about the material; reads it carefully; reflect on its meaning while it is being read; recites as much of the material as possible; and finally, reviews the material, using the questions developed before begininning reading.

This is a useful method, but it lacks criteria for applicability. For the learner, there is a cost/benefit ratio that is constantly being unconsciously assessed. PQ4R is a lot of work, and if the perceived benefit isn't adequate the learner will quickly abandon it. Recitation in particular is unlikely to be popular, especially since the empirical evidence supporting its effect on learning and retention is less than compelling.

Related techniques

Those in these sections and the sections about complex memory tricks.

References

Kylonnen and Alluisi

PRACTICE ALONE

Description

Observing a trainee during practice will make the practice into something of a performance in itself. A person trying to practice with another person in the room tends to have less ability to monitor what he or she is doing. The performance beomes monitored rather than skills. Practice alone occurs without an observer and leads to more ability to concentrate, and therefore more efficient practice.

How to do it

Give the trainee an assignment and leave the room. Research shows that the presence of another person, even one who is paying no attention at all, can effect concentration. The presence of a trainer - the person whose opinion counts the most - may have an especially strong effect.

Following sessions where the trainer teaches new skills and provides feedback and reinforcement, the trainee will simply need practice. This is then achieved best alone. It can be difficult to judge when trainees have enough information both to make advances and to accurately monitor their performance. Nevertheless, it is important to allow frequent opportunities for practice alone. It is equally important to also occasionally use supervised practice to ensure wrong skills are not unintentionally being learned during practice alone.

If skills are going to be used around others, observed practice should also be used once trainees have reached a satisfactory standard. In this way, trainees become used to performing or simply working in front of other people. This is necessary in order to ensure that skills learned transfer to the actual environment where they will be used.

Indicators

Practice alone is useful for people who are practicing something that requires concentration and that has observable consequences. It is especially applicable when the skills are oriented to performance where mistakes are highly visible and detrimental to the value of performance.

Counterindicators

Practice alone is unnecessary when a trainee has reached performance standard. In this case, performance itself can increase drive and standards so an observer will lead to training benefits. In addition, the narrowed attention resulting from observed practice may suit simple tasks which do not require the trainee's full mental resources. Less motivated individuals will also accomplish less alone. They will do better in supervised practice.

Common problems

Without feedback there is the possibility that bad habits will become established with unobserved practice. Use a balance of practice alone with supervised sessions.

Motivation may lag when the person is practicing alone. Again, practice alone combined with other training techniques should lessen this problem.

Related techniques

Deliberate Practice
Covert practice
Learn by doing only
Limit introduction
Instruction
Establish an environment
Feedback - Action vs Learning
Advance and back off

References

Orasanu and Backer

RECODING

Description

Information that is bland and uninteresting (such as a set of numbers or letters) can be recoded in a more accessible way.

How to do it

The to-be-remembered item is recoded in a more accessible way. For example, the phone comes with letters to go along with the numbers. A random set of numbers is hard to remember. So make words out of the letters, because words are a lot easier to remember than letters, and you can associate the word with the person you want to call. Or, you can think of the numbers as race times, baseball statistics, or birthdays. Or, you can recode the numbers in terms of number facts, e.g., if the phone number is 777-3610, it is three 7's, then 3, then 3 + 3, then 3+3+4.

Related techniques

Those in these sections and the sections about complex memory tricks.

References

Kyllonen & Alluisi

SELF-EXPLANATION

Description
Generating explanations for yourself as you read boosts comprehension of complex material.

How it works
Chi et al (1994) found that comprehension was boosted significantly by generating explanations for read material. Their experiment had high school students read a selection from a popular biology text. The control group read it through twice. The test group read it once, but (as instructed) stopped after each sentence and generated an explanation for themselves about what it meant. The explainers understood the passage much better than the twice-readers.

Especially interesting, one of the Chi team's results was that the self-explainers frequently generated false hypotheses, but that these were self-correcting. Apparently because they were self-articulated, the students took pains to check and correct them. In effect, they used hypotheses as they are supposed to be used, as mental tools to guide investigation.

Indicators
Any situation involving reading, understanding, and retaining complex information.

Counterindicators
Tasks that don't involve reading complex information.

Common problems
It takes work and requires breaking long-standing habits.

Related techniques
Mental simulation

References
Chi et al

SEQUENCING: COMPLETE OR SIMPLIFIED

Description
This approach is a choice between teaching the fundamentals of a task first or allowing trainees to start immediately on the full task. Tackling basics, task components, or simplified versions of the task can be time consuming and boring, but may be easier in the short term, and produce more thorough, longer lasting results. Practicing the actual task may allow the trainee to develop whatever fundamentals are necessary while actually doing it. More effort may be required at first, but greater challenge is provided. Whichever is chosen first, the two approaches can be combined in a flexible sequence to meet trainees' developing needs.

How to do it
Simplified task first: The most basic method of simplification is to break the task down into its components. Avoid training isolated skills in ways which are inappropriate for the actual task. It is useful to begin with skills which easily become automatic. This frees up cognitive resources to be used during the task, and increases speed and accuracy (see Automaticity).

A simplified version of the whole task can also be created. This can be done in several ways: Remove elements from it (see Adaptive Training); simplify the required responses while leaving the task the same; change the required responses. The danger with simplification is that trainees may learn to carry out actions in ways which are unsuitable to the actual task. In the long term this may mean the full task is harder to teach. In the meantime, however, a through understanding of the basics involved will hav been gained without overwhelming the trainees.

Simplification is improved if instructions, guidance, safety nets, feedback, and reinforcement are built in for every step. You may want to focus particularly on the most difficult parts, actually segmenting the task and applying a full range of training techniques at every stage.

Train without time stress. Time stress causes trainees to simplify their approach and ignore information in order to make the task easier.

(This may be appropriate when sequencing the complete task first.)

If the task requires conceptual knowledge, mental models, strategies and other things that necessitate cognitive processes during the task, these can be taught explicitly to the student near the beginning of the training. As training becomes more complicated, the trainees will be able to use their basic understanding, and to practice the cognitive skills they will use in the task. However, if the task requires doing an action faster than these reasoning strategies allows, teach a heuristic approach instead (see Don't Take Your Time - Heuristics). In this way, trainees will develop the necessary cognitive processes reflectively, in tandem with training.

Motivation should be monitored when using simplified first. Trainees can become discouraged if the complete task goal is too far off. Use other training techniques to maintain a positive mood, establish an environment and use contract theory.

Complete task first: Start with the full-on, hard version while still maintaining standard training such as feedback and new skill teaching. This approach can be supplemented with others such as training with a timer and, as with simplified tasks, heuristics.

It is important to monitor whether skills fail in any particular area. When this occurs, be prepared to switch to simplified task teaching. One advantage of sequencing complete tasks first is that it can reveal where trainee skills are weak and enable training to adjust accordingly.

Using complete task training first, it is likely that you will find that the trainee is able to make a lot of progress for a while, but will slow down. This contrasts with those who are started on fundamentals who will find doing the whole task relatively difficult at first, but will have the capacity to improve.

Indicators
It makes sense to sequence the complete task first when the task is simple, or only to be performed a few times. In addition, some tasks do not contain fundamentals which could be taught as components or in simplified versions. Other tasks may not need to be performed

perfectly or with full understanding and are therefore suitable to teach in their complete state. Sometimes time constraints may lead to the complete task being taught first. Some trainees may respond well to challenges and would therefore benefit from complete task training.

Sequencing simplified task teaching first is suitable when the ultimate performance standard is very distant, the task is very complex, or the task is hard to understand. If the components of a task are not highly interdependent, and they employ different skills, simplified first will probably be the optimum sequence. If there are elements of the task that the person is likely to learn incorrectly, never learn, or not learn optimally when carrying out the full task, these are suitable for a simplified approach. Because a thorough, automatic and lasting understanding is gained of basic components, simplified first sequencing is appropriate when the long term aim is for the task to be completed efficiently and fast.

Counterindicators
This is mainly covered by the factors leading to a choice of one sequence over the other. Be prepared to switch from one task training approach to the other as trainee skill levels and understanding indicate. It should also be noted that the cost of training on some complete tasks may be prohibitive.

Common problems
Changing the task to make it easier may make it boring. Simplifying the task can also make it harder for trainees to advance. It's been shown that people learn more easily about new activities than ones to which they are accustomed. Be prepared with many versions of varying difficulty and different approaches. Monitor mood and use training techniques such as establishing an environment and socialization.

If you sequence the complete task first, monitor trainee understanding. The task itself may be challenging and stimulate fast learning of several things at once. However, it may also lead to an artificially simplified and incomplete understanding. Again, monitoring and flexibility between the two sequences are key.

Related Techniques

Automaticity
Learn by mucking about
Train with a timer
Don't take your time: heuristics
Overlearning

References
Holding
Glaser and Bassok
Salas, Driskell, Hughes

SHAPING

Description
Shaping is a training approach based on reinforcement of successive approximations to the desired behavior. Shaping is good for development of behavioral responses to perceived circumstances. "Behavioral" is placed in mild contrast here with "mental," since conscious awareness of the shaping process, or even of the contingency of the reinforcement on the behavior, is not required for shaping to work. Shaping is based on the principle that actions that are rewarded are more likely to occur in the future.

How to do it
Shaping works through reinforcement. Reinforcement can be anything a trainee wants. Reinforcement is like reward, with the crucial distinction that it only counts as reinforcement if (a) it happens in close conjunction with an act, and (b) it increases (positive reinforcement) or decreases (negative reinforcement) the likelihood of the act occurring again.

Both elements of this definition count. First, conjunction with the act is important. The greater the distance in time (or the greater the psychological distance), the weaker the shaping effect. When the receiver makes the touchdown catch and the stadium explodes, that's positive reinforcement. When the grant is awarded fourteen months after the grant proposal was submitted, that's reward, but it's not reinforcement.

Second, in shaping, "positive" and "negative" reinforcements are defined solely in terms of the likelihood of the target action recurring. They are not defined in terms of emotional qualities. For example, if a lonely, neglected child cannot get attention in any other way, then the scolding that follows misbehavior is positive reinforcement. The child has found a way to get attention, something he or she wants. The emotionally negative scolding is actually a strong positive reinforcement.

"Successive approximation" assumes you aren't starting out with the behavior you want. To shape the behavior, movement in the direction of the desired behavior—"approximation"—is reinforced. Learning

proceeds in steps, with each approximation growing closer to the desired behavior. For this to happen, the learner must *vary* in behavior. The learner must try things, experiment and explore, so that the shaper can reinforce successively closer approximations.

The basic process of shaping is to reinforce closer and closer approximations of the desired behavior, so as to eventually arrive at the desired performance. There are ten "laws" of shaping (from Karen Pryor):

1. Raise criteria in increments small enough that the trainee has a reasonable chance for reinforcement.

You want the trainee to succeed. How fast you "raise the bar" is not a function of the potential you perceive in the trainee. Instead, it depends on how well you communicate through the shaping procedure what patterns of behavior get reinforcement. It's useful to note here that "communication" should not be confused with the words spoken by the trainer. Some psychologists like to use the metaphor of "the words and the music". The words are part of the message, but people are normally highly sensitive to the way the words are spoken (the "music"). One person can say "that was OK" and make it a powerful positive reinforcement. Another can say "that was great" and turn it into a strong negative reinforcement. In general, the music counts much more than the words.

2. Train one thing at a time.

This doesn't mean one task at a time. It simply means that if you are training a particular subtask, work on only one aspect of it at a time. If you are training the drive off the tee in golf, and you are working on the follow-through, then just work on the follow-through until it is mastered. However the subgoals or processes of a task are broken out, training should approach them one at a time.

3. Always put the current response on a variable schedule of reinforcement before adding or raising criteria.

"Variable schedule" simply means that once the response is learned, the reinforcement does not always automatically follow. Variable reinforcement has been shown repeatedly to strengthen the learned response. When you can safely reinforce only some of the time and still get the right behavior, you can then reinforce only the best examples of the behavior.

4. When introducing new criteria, relax the old ones.
This is similar in spirit to only doing one thing at a time. When there is a new subtask to be learned, then concentrate on it. Make integrating it with previously learned subtasks a distinct and subsequent learning step.

5. Stay ahead of your trainee.
This means that if the trainee makes sudden progress, or even a breakthrough, you know what to reinforce next.

6. Don't change trainers in midstream.
This does not mean there cannot be different trainers for different behaviors working at the same (general) time. It does mean that the relationship between the trainer and the trainee should be respected and not disrupted.

7. If one shaping approach is not working, try another one.
While this sounds pretty straightforward, it can happen that a trainer develops a belief in his or her "best" way of training and blames the trainee for failing to learn. Shaping is a highly cooperative venture, and if the trainer is not seeing progress, the right thing to do is to try a different approach, a different breakout of subtask elements, or a different reinforcement.

8. Don't interrupt a training session gratuitously.
If the trainee is expected to give his or her full attention to the training session, then the trainer should be at least as committed. Removal of attention is a powerful rebuke. If a rebuke is appropriate, attention removal can be used, but if it is used carelessly, e.g., to answer a telephone in the middle of a session, the trainee has learned that the trainer can't be trusted in his or her committment to the training. The training must not be very important, then.

9. If behavior deteriorates, go back to the basics and provide easy reinforcements.
If for example the learner gets frustrated learning to juggle, then you reinforce her for just trowing the balls up, not too hard, and gradually build the behavior back up, and along with it, her confidence. Note that you are rewarding the subject for performing some behavior, but you must also make sure the learner is rewarded for participating in

the learning process itself.

10. End every training session on a high note.
If necessary, stop earlier than planned to do this. If scheduling problems make stopping early impossible, or if fatigue starts to interfere with performance, have the last section of the training session focus on a high-confidence activity, one that is sure to garner reinforcement. The concomitant of this is, never introduce new and difficult tasks at the end of a training session. That will simply train a feeling of inadequacy in association with the training in general.

Measures of effectiveness for shaping are typically simple, i.e., the target level of task performance. Because the first part of shaping is to "disassemble" the task, setting up MOEs can take advantage of this preparatory work. MOEs of course need to respect normal performance limits of the trainees. No amount of brilliant shaping will get someone to run 100 meters in five seconds or juggle thirty clubs.

The cost of shaping is typically more in the form of ingenuity and hard work on the part of the trainer, rather than in dollar costs associated with development of curricula, simulations, or training systems. There are no particular overhead costs with shaping. Shaping is a low-dollar, high-mental-investment approach.

Indicators
Shaping, carefully applied, can be extremely powerful in modifying behavior. It has even been used to train pigeons to play ping-pong. It is a technique for developing reliable performance of complex behaviors. In particular, if a pattern of behavior requires intelligence, but not necessarily conscious control, shaping is an appropriate technique. Examples of "intelligent but not consciously controlled" behavior include real-time performance (sports, some aspects of firefighting, some military activities), and performance where motivational or attitudinal aspects are crucial, e.g., meeting new people and making them feel at ease.

Counterindicators
Shaping is an inefficient approach if the range of possible responses is both wide and internally dissimilar, or if a great deal of conscious control is required to perform a task. Examples of the former include

design tasks where there are relatively few constraints, and most artistic composition tasks. Examples of the latter are scientific, mathematical, or technical problem-solving skills. However, note that in both of these cases, while shaping would not be useful as a primary technique, it could be useful as a supporting technique.

While shaping is almost always applicable to physical skills, it is not the approach of choice for problem-solving skills. Nor is it the choice if there are explicit rules or procedures that can be consciously followed to achieve the desired goal.

Shaping is not for the intellectually or attentionally lazy trainer. A fairly high skill level is needed to be effective. Instructors need to exercise their analytical sides to plan shaping, and their intuitive sides to carry it out. Instructors must be able to pay very close attention to the trainees, and to fully engage in working with them. There are four basic skills or requirements:

1. Know exactly what you want, in whatever level of detail is necessary.
2. Pay very close attention.
3. Know what is good enough to be reinforced, and what isn't, that is, at what level to "put the bar."
4. Know what is reinforcing for the individual learner.

Common problems

Planning problems occur when the breakdown of the task to be performed does not correspond to distinct behaviors, and when the plan is incomplete. Implementation problems can stem from trainer rigidity ("this is how we do it, goddamit"), inadequate reinforcement, over-reinforcement (the general rule is, use the smallest effective reinforcement), and impatience.

A special class of implementation problems can arise when the trainer (unintentionally) confuses trying with goal achievement. It may be the case that "trying" is the target behavior, in which case reinforcement of trying is good shaping. This sometimes occurs when the correct result is self-reinforcing (like in juggling, for instance), and the learner's hurdle is to learn to try. However, if the desired performance is is not strongly self-reinforcing, then reinforcing trying only trains the student to try, but not necessarily to succeed.

Related techniques for the same training problem(s)
Pure reinforcement is similar to shaping, with the difference that approximations to the goal behavior are not reinforced, only the goal behavior itself.

Classroom lecture is an inverse approach. Good teachers actually use shaping techniques (often unconsciously). The classroom setting, though, and the classical classroom approach of standardized information being provided verbally to a room full of students, is the opposite of shaping.

Unsupervised exploration ("sink or swim") is the trainerless version of shaping. In "sink or swim", the trainee becomes his or her own trainer, monitoring the environment for cues as to progress, with the perception of a step forward being the reinforcement for whatever action led to it. This kind of training often leads to real behavioral inefficiencies, since random actions that happen to correlate with success become ingrained. Baseball pitchers who have a ritualized nineteen-step routine before every pitch display this kind of behavior. If you adjust the brim of your hat immediately before a good pitch, you're more likely to adjust the brim of your hat before every pitch. In realtime domains such as emergency medicine, unnecessary actions are undesirable.

In some cases inefficiency will simply need to be accepted. We animals have a tendency to stick with what works, even if it isn't perfect (Herbert Simon won a Nobel Prize in Economics for pointing this out.) If the learner develops a pattern that leads to the desired behaviors but includes a few idiosyncracies, well, the learner is never the same as the teacher.

Unsupervised exploration should not be confused with task immersion. Task immersion occcurs when the learner has achieved sufficient grounding in the task to be placed in the task environment and allowed to actually perfrom the task. Task immersion is often structured to provide exposure to the easy or moderate aspects of the task in a graded fashion, and is rarely used when there will not be supervision and support available if needed. Nor is it used when there isn't already evidence that the learner will be able to perform the desired task(s). "Sink or swim" is task immersion without

safeguards or evidence, which makes it a different thing entirely.

References

1984. Pryor, Karen. Don't Shoot the Dog. New York: Simon & Schuster.

SOCIALIZATION

Description

Socialization occurs naturally in a new training or work environment. New entrants automatically adopt prevailing attititudes, moods, and expectations. Socialization as a training technique uses the processes involved so they become an aid to more effective work or training. Socialization is especially useful as training or work begin.

How to do it

The effects of socialization are thought to be continuous. However, socialization most strongly influences work or training at the beginning. Socialization effects make initial encounters very important. This is true in totally new environments, but it is also seen when entering a new department, starting with a new partner, entering a new project, or whenever the work or training environment changes. Use socialization in these situations because attitudes are more open and more easily influenced than usual.

It's been shown that people are born conformists and learn well from social cues and patterns. Socialization is a conscious effort to direct these natural and powerful tendencies in a constructive manner. You can help make socialization positive by first ensuring the desirable attitudes, moods and expectations are clearly and easily perceived. Make an effort to create a good first impression. It helps to provide guidance so that the trainee feels comfortable, confident, and effective. Ensure the work or training is already running in a way which rewards the type of behaviour you would like new entrants to adopt.

Specific supplementary techniques to use are the buddy system, organized support groups, and mentors. These approaches potentially help with transfer, because, when buddies, groups and mentors are chosen with care, they produce exchanges which reinforce learnings.

One important aim is to establish a climate where learning and training are encouraged and considered important. This is easily demonstrated if others, including the trainer or manager are also undergoing training and are seen to take it seriously. Leading by

example will also contribute to positive socialization.

Indicators
Use socialization when someone is first entering a new environment, or if the environment is changing. Also use it if there is a strong need for esprit du corps.

Counterindicators
If long term attitudes are not involved you may not want to put effort into socialization. However, socialization can have an effect even on short training sessions and temporary jobs. It can be adequately accomplished by the existence alone of a successful working group.

Common problems
So much effort can go into socialization that it provides a false impression. Credibility may be lost, and disappointment can set in when the reality is discovered. If negative situations exist, socialization can partly be based on positive and honest attitudes etc. about resolving the problems involved.

Related techniques
Expectations of training
Establish an environment
Choices about training
Contract theory
Attitude - Locus of control
Making training seem important
Lead by example - attitude
Mentors
Groups - reward structure
Paired post-training
Teams - cooperative controversy

References
Chao

PROBLEM SOLVING WITHOUT EXAMPLES

Description
Oftentimes when we are asked to solve problems we do so by modeling our solution on other problems for which we already have solutions. This may make things easier in the short run, but it may hinder long-term learning.

How to do it
If you are using problem solving as a form of instruction, then what you might want to do is *not* give them something to model their answers on. If they have a similar problem, then to solve the new problem the learner may be able to "proceed" by matching the surface features of the problem without understanding its underlying structure.

If no sample upon which to model their work is available, the learner has no alternative but to figure the problem out from principles. Assuming those are what you want the person to learn, this is a desirable result.

Some caution is needed to make the level of challenge appropriate. If the learner is unable to orient himself or herself, then discouragement and a dislike of the subject are likely outcomes.

Related techniques
Those in these sections and the sections about simple memory tricks.

References
Kyllonen and Alluisi

STRESS - CRITERION SITUATION PRACTICE

Description
When the task is stressful, it is often not feasible to practice it in its full form. But it is important for the learner to encounter and learn to deal with the stress that he or she will encounter in the actual task.

How to do it
Putting people in what are called criterion situations can help. A "criterion situation" in training reproduces the intensity of actual task performance. It helps with generalization, physiological defenses/toughness, and it can reduce uncertainty and fear.

Exposing someone to stress allows them to become used to it. It also means that they will form a realistic idea of what the situation is like, which will probably lower the amount of stress they feel when encountering it (unless it is really more dangerous than they thought, in which case they probably shouldn't be doing it anyway).

Exposing someone to stress lets them learn to predict what will happen next, and recognize possible problems/danger, but also when there is nothing to worry about.

Letting the person practice doing the actual task in the criterion situation is important because it allows the person to generalize the learning they have done to a new and different situation, to practice it there, and to dealing with the stress and the task together.

Unfortunately, criterion situation training can also hurt. It can interfere with task acquisition (learning), instill fears and sensitivity, lower confidence, create despair, and cause exhaustion.

In designing and administering a criterion training event, the following guidelines can be used:
1. Trainees should be allowed to familiarize themselves with the stressors
2. Their confidence should not be crushed by exposure to high stress while performing task
3. Stress should not be allowed to hinder acquisition of skills or to create unrealistic expectations or strategies

Indicators
This is useful when the task is stressful and when the causes of the stress can be credibly reproduced in a training environment.

Counterindicators
If the task is not stressful, do not use this.

Common problems
Stress makes people narrow their focus, and in doing so can hinder practice ability, by not allowing people to use their full range of cognitive abilities, or concentrate on all of what they are doing. It also makes people pay attention to things other than what they are being trained on. This means less ability to concentrate. Both of these things hinder the person's ability to learn. Learning to do the task away from the stress solves these problems (to a good extent).

If trainees are experiencing too much stress, give them more time to get used to it and lower the difficulty of the task. Or, if trainees' confidence seems to wane, if they dread training, or are exhausted by it, easing off is appropriate.

Related techniques
Stress - Graduated Training
Stress - Phased Training
Stress - Emotional Training
Stress - Full Information
Automatization
Overlearning
Games and Simulations
Expectations Of Training
Train With A Timer
Don't Take Your Time - Heuristics
Sequence - Hard Or Easy
Easy First

References
Keinan and Friedland

EMOTIONAL TRAINING FOR STRESS

Description

There are two ways to deal with stress. Problem solving techniques are ways to become better at managing the environment - so that it is less stressful and so that you feel better about yourself. Emotional techniques are used to manage yourself - not change the environment, but to relax, let yourself focus, etc.

This section has to do with the emotional techniques. There is a suggestion about how to best make use of problem solving techniques, but no specific ways of changing the environment to make it less stressful.

How to do it

Less uncertainty and more feeling of control mean less emotional stress. Stress disrupts normal thinking processes - it makes it hard to retrieve things from memory and it makes it hard to organize and focus your thoughts. (More accurately, it is easy to focus, but not on the right things.) A three-phased approach can be used.

Phase One is to convince them (or confirm for them) that they will be able to control their reactions. This is the most important step.

Phase Two is to train them in skills stress-management skills while not under stress. For example:

- Thought restructuring, where negative reactions and thoughts are replaced with coping thoughts and reactions, or attention is consciously redirected.
- Physiological control, such as breathing and muscle relaxation exercises. Reducing the physical signs of stress, such as tenseness and heavy breathing, will "trick" you into thinking that the situation is less stressful than it seems when you are breathing hard.

There is some research that suggests using videotapes of people modeling good coping, role playing, and demonstrating problems that can be managed with these techniques all help, as do training sessions of at least one hour with a good trainer. (But it's hard to get too excited over these particular findings, given the measurement problems and the interest of the researches to find what they were

looking for.) It is important to provide feedback, so that the trainee can evaluate his or her progress.

Phase Three is to let them practice these things in the stressful situation, or alternately in a graduated introduction of the task stressors. As the trainees habituate to the situation, they will become desensitized, and they will also learn to recognize what should and what should not cause alarm, which will reduce the stress effect.

Problem solving methods are preferable, but can be used in combination with an emotional approach if the level of stress needs to be reduced more than is being done by the problem solving approach alone, or the degree of efficacy of the problem solving methods for control of the environment is limited.

Indicators
These techniques are to be used when trainees' ability to perform is impaired because of too much stress. Emotional techniques are useful when the problem is a stressful event that the person can do nothing about, i.e., they cannot change the environment. Emotional training is especially helpful for events that are brief in duration.

Counterindicators
If the stressor is something that the person can change, emotional techniques may be still useful (depending on the stress level), but should be used in support of (and clearly as an adjunct to) behaviors that change the environment.

Emotional training helps with stress that causes anxiety or depression, but not with things like sleep deprivation, noise, heat, cold or altitude.

Common problems
Over-desensitization is possible, where the energy that the stress stimulates is diluted. This can result in lower levels of concentration and commitment to task completion.

It is also true that some kinds of emotional stress cannot be simulated - for example, all heart surgeons "lose" patients (a euphemism for having the people they're caring for die). In those

cases, socialization and team-oriented support is appropriate.

Related techniques
Stress - Full information
Stress - Graduated training
Stress - Phased training
Stress - Criterion practice
Socialization

References
Keinan and Friedland
Johnston and Cannon-Bowers
Orasanu and Becker

STRESS - FULL INFORMATION

Description

Giving people full information about what they may encounter can lead to problems when it is actually encountered. Arousal can be heightened to a damaging degree, overly-aggressive reactions can be made more likely, and so on. However, it can also be harmful to tell they don't need to worry if that misrepresents the actual task situation. Ideally, learners should be given the optimal amount of preparatory (warning) information when training for very stressful tasks.

How to do it

When people know what to expect, they can make themselves more ready for it, increase their alertness, and be primed to respond effectively. Realistic expectations attenuate stress and improve performance. Therefore, this approach advocates telling trainees what might happen, in conjunction with their performance training. Combining appropriate expectations with developing task competence gives trainees a sense of control.

There are three steps.

1. Tell them they can do it, reassure them, tell them (or better, show them) others have done it before them.
2. Tell them when it is going to start, and also when it is going to stop. Telling people how many missions they have to fly reduces stress, and telling them how much further they have to march not only helps mentally, but in one study it actually changed the composition of blood samples taken partway through.
3. Tell them how to monitor the situation and provide them with feedback-rich practice opportunities, so they can confidently tell when things are going well, and when the danger/pressure is and is not present.

The types of information that can be provided include:

1. Sensory information, so that they can appropriately interpret what they feel, see, hear, etc., without panic
2. Procedural information, that is, what to expect, what sequences are typical, and common errors to avoid.
3. Instrumental information, so that they know specific techniques to cope with the stressors and their effects. Having such

techniques gives trainees both actual and perceived control over the task situation.

If there is information that will neither make trainees do better or feel better, there is no reason to provide it, especially if it is likely to heighten stress when the event occurs.

But trainees should not be told there is nothing to worry about if there is. Unreliable (false) information is bad, even if it is temporarily reassuring, because its invalidation when events actually happen can make things worse by casting doubt on the reliability of other elements of their training.

Indicators
The suggestions above are for tasks that involve (at least potentially) very high levels of stress - where there may be fear and danger. The method is also applicable where trainees may be made very uncomfortable by the task situation.

In these situations, the amount of information trainees have about what is happening and what is going to happen is very important to maintenance of a positive attitude.

The more useful a piece of information is to the person, the worse an idea it is to withhold it, even if providing the information will heighten stress.

Counterindicators
If reactions to the particular stressors of the task domain are highly variable - for example, some people find public speaking so anxiety-provoking as to lead to nausea, while others relish it - then building expectations of stress may themselves introduce stress.

Common problems
If trainees develop fears of training before they start practicing (after only being told about it), or if they overreact to certain stressors, they may be being too much.

If people are told what to worry about without being told what to do about it, stress that could be avoided without withholding information is probably being created.

If a trainee does something and his or her fears are not realized, he or she gains self-efficacy. However, if the trainee does something and gets scared or overly upset, then even if he or she accomplishes the task, he or she will still lose self-efficacy. It is the trainer's responsibility to create an environment and an atmosphere where trainees can practice the task under stress without these conditions becoming overwhelming.

Related techniques

Stress - Criterion Practice
Stress - Emotional Training
Stress - Graduated Training
Stress - Phased Training
Enactive Mastery
Limit Introduction
Don't Take Your Time - Heuristics
Attitude - Locus Of Control
Feedback - Delay It
Feedback - Withhold It

References

Keinan and Friedland
Latham

STRESS - GRADUATED TRAINING

Description
Sometimes a task is too stressful for immediate, immersive practice. The technique here is to start with mild levels of stress, and gradually increase the realism until the the desired level ("criterion level") is reached.

How to do it
In graduated training, stressors are introduced into the practice environment according to these two guidelines:

1. Do not proceed to the next level until an acceptable degree of proficiency is reached. Otherwise the additional stress will simply make it harder for learning to be achieved. It may actually cause the trainees to learn things that are not true, and thereby get worse, not better. (For the problems this can cause, see Automaticity and Overlearning).
2. Tell trainees what levels of stress they can expect to reach, or they may fall into despair. One study found that when trainees are not told they have reached the limit, they do less well than when they are. Trainees may loose confidence or give up if they think they will not be able to make it. Conversely, it is reassuring and rewarding to think you will.

Indicators
This method can be used when there are high levels of stress requiring gradual adaptation.

Counterindicators
If stressors come in discrete "packets," such that they cannot be decomposed into elements that can be introduced gradually, this method cannot be applied.

Common problems
Trainees' self-reports on adaptation may not be reliable, so performance should be carefully monitored and impatience avoided.

Related techniques
Stress - Criterion Practice
Stress - Phased Training
Stress - Emotional Training

Automatization
Overlearning
Don't Take Your Time - Heuristics
Sequence - Hard Or Easy
Easy First

References
Keinan and Friedland

STRESS - PHASED TRAINING

Description
Instead of placing a trainee directly into a training situation that is highly stressful, this method suggests three distinct phases, intended to allow the trainee to become accustomed to the stress and also to learn the skills well.

How to do it
Keinan and Friedland propose three requirements for stress training:
1. Trainees should be allowed to familiarize themselves with the stressors.
2. Their confidence should not be crushed by exposure to high stress while performing task.
3. Stress should not be allowed to hinder acquisition of skills or to create unrealistic expectations or strategies.

Following this philosophy, they recommend a three-phased training approach.
1. In Phase 1, train the subject to do the task under minimal stress.
2. In Phase 2, expose the subject to the stressors they can expect without asking them to do anything.
3. In Phase 3, have the trainees perform the task under the criterion level of the stressors.

However, in experiments by the authors, the finding emerged that just steps 1 and 3 together worked as well as steps 1, 2, and 3. Neither 1 and 2 only, 1 only, nor 3 only were as effective.

Indicators
This technique can be effective if the stressors can be separated and manipulated independently from the skills of performance.

Counterindicators
If dealing with the stressors is intrinsic to the task skill, this technique is inapplicable.

Common problems
The issues for this method are rate of introduction of stressors and stressor realism. Both need to be carefully managed to achieve effective transfer.

Related techniques
Stress - Graduated Training
Stress - Criterion Practice
Stress - Emotional Training
Automatization
Overlearning
Don't Take Your Time - Heuristics
Sequence - Hard Or Easy
Easy First

References
Keinan and Friedland

SUMMARIZE FOR THE CLASS

Description
Oftentimes it is easy to go through a lecture without really putting much thought into what is being said. This technique is a way to make students responsible for knowing what was said, and for understanding what the material really means.

How to do it
The method has students read (or watch a lecture or movie or whatever), then summarize the content for the class. The student should be encouraged to ask questions that get at the heart of what they have just learned, and in turn to answer questions when they are summerizing.

It can be useful for the teacher model this behavior (by summarizing and asking questions) before the students are asked to do it. When they begin, it may be supportive to be prompted by the teacher at first. As they develop the necessary skills they can summarize on their own.

A useful variation is to have the students summarize and formulate questions on their own.

When the learner knows that he or she is going to have to come up with the important questions at the end of the day, he or she is likely to:

- Think about the subject matter with the goal of understanding it (not just listening to it, as we often do, I think).
- Think about what the most important things to come away understanding are (so he or she can ask questions about them).
- Think about what parts of it make sense with respect to other things already known (the ones that don't the learner is highly motivated to question).
- Know the answers to his or her own questions.

This approach is appropriate for instructional settings - lecture, movie, classroom, reading - where the learner doesn't either need or get to do a lot of practicing.

If the subject matter is not complex, and does not have some sort of

interesting structure intrinsic to it (e.g., memorizing zip codes), this method is inappropriate. It is unlikely to be applicable to procedural knowledge.

Example

"I sit through class everyday, bored. Then one day the teacher points at me and says 'You are going to lead the class in a discussion by asking them questions at the end of today's class.'

"So I open up my notebook, and start taking notes. I think about what the teacher says, and each thing that comes up I say 'what do I think of that? Do I believe it? Do I know something else about it that is interesting? Does it make sense with the other things that I have learned about today in class? Or on other days in class? Is there anything about it that is worth discussing, or that I doubt or don't understand? And is this the answer to that other question that I had before?' All of these things make me really think about the lecture as I go through it, and not only think about what is being said, but about its importance, why it matters, and other things I know.

"At the end of class, I have a much better understanding of what was said than I did in other classes becuase I have participated in my own learning.

"I then pick the things that I think are the most important, out of the questions that I have thought of. And I bring them up. When I do, the class response lets me know what I missed and what I am unable to explain, and of course what I got right."

Related techniques

Those in these sections and the sections about simple memory tricks.

References

Glasser and Bassok

TEAMS: CROSS TRAINING

Description
In cross training team members train a little bit in other people's positions. By learning what other team members have to do during a task, they can anticipate their needs, and understand an overall framework. In this way, team members become more efficient, and the whole team learns to coordinate without unnecessary communication.

How to do it
Have team members rotate from position to position or from role to role during practice sessions. Limit the number of people switching at any one time or performance levels are likely to drop to a point where the task falls apart.

Rotation can occur with the whole task or on simplified versions. When job rotation is not feasible because of safety, for example, provide controlled simulations instead of the real thing. If a position or role involves complicated actions, it's probably wise to allow a short period of passive observation before the trainee switches to it.

Role or position switching, timed well, and probably without the whole team, may also be useful to resolve persistent mistakes without excessive criticism: A trainee can take the role where he experiences the effect of something he has been doing incorrectly. This may be enough to reveal, for example, a misunderstood priority or inaccurate procedure.

Allow time for feedback and watch for improved efficiency in both original roles and overall team performance. Ask for accurate explanations from team members about their teammates' behavior, and for descriptions of their needs. Trainees' understanding should increase with respect to why other team members do what they do, what difficulties are involved, and how their own actions effect those of others. Interdependence and mutual responsibility will become clearer.

Indicators
You may want to use cross training if:

- Interdependence is important.
- Team members need to understand what the others are doing and why.
- Team members need to anticipate each others actions.
- Team members need greater understanding of teammates' needs.

The more different the different jobs or roles are, the more useful cross training is.

Counterindicators
Cross training can be wasteful if time is limited and would be better devoted to each trainee learning his or her own part. Some tasks may be too simple to provide any benefits from cross training. Others may involve highly specialized roles which make cross training either unnecessary or impossible. In some group training, team members may work together, but without relying on each other for task performance.

Common problems
Original team members for any role or position may be too eager to correct trainees new to the role or position. Make sure all members are aware that time will be set aside for commentary and feedback. Some team members may feel work on roles beside their own is a waste of time. Use socialization and a positive environment to get over this. Cooperative controversy may also be useful here.

Related techniques
Teams - cooperative controversy
Enactive mastery
Contract theory
Behavioral modeling

References
Kozlowski and Salas
Salas, Cannon-Bowers, and Blickensderfer

TEAMS - GENERAL METHODS

Description
When people have to work as teams, how team members interact is important. It can be helpful to train the team in teamwork skills.

How to do it
The more people need to coordinate and the more they rely on each other, the more benefit they will derive from team tasks. The need for teamwork exists when:

- There is a great deal of interdependence.
- Environmental stability is low. If a task involves a lot of variability and/or unpredictability, the team is going to benefit more from being able to work as a team - monitoring each other, predicting responses, working toward the same goal, anticipation, all of which are more important with less environmental stability.
- There is low team member turnover.
- There is low membership in multiple teams.
- There are many different tasks the team must perform.

The more these things are true, the more important it is to train the members to work as a team.

When a team has to function under stress, or in trying circumstances, it is especially important for them them to be able to rely on each other, have a common goal, anticipate each other, and so on: It is especially important that they work as a team.

Teamwork skills training should:

1. Focus on teamwork skills, such as communication, compensatory behavior, leadership, assertiveness, decision making, planning, situational awareness.
2. Provide information on teamwork, demonstrations of it, practice (role playing and simulation) of teamwork, and feedback on teamwork quality.
3. Provide for measurement and diagnosis of skills from moment to moment.
4. Provide both experience and confidence in working as a team when faced with a given task.
5. Provide training in "generic" teamwork skills such as communication and leadership, and interpersonal skills.

When small groups of people work together towards a common goal, possibly because they are relying on each other and/or because they are doing things for one another, they tend to form a bond. This can enhance the teamwork effect.

Common problems
Egotistical team members can be an issue. Firm leadership can ameliorate this to some extent.

Related techniques
Teams - Cross training
Cooperative learning

References
Salas, Cannon-Bowers, and Blickensderfer
Orasanu and Backer
Holding
Baldwin and Magjuka
Kozlowski and Salas

TEAMS: COOPERATIVE CONTROVERSY

Description
Cooperative controversy trains team members to maximize the effectiveness of cooperation. It does this by encouraging constructive opposition and exploration of new ideas. This occurs within a framework of established norms for friendly, honest exchange and feedback.

How to do it
This approach is based on several premises which ideally should be integral to all training. Establish that everyone is "in this together." Insults and personal attack are unacceptable - ideas, not people are open to challenge. Force and dominance are not permitted, persuasion and respect are. Questions are welcome as well as other techniques to clarify information and to understand other people's perspectives. The golden rule for everyone involved: Bring things up with others as you would want them to do with you; listen to them, as you would want them to listen to you.

Explain that you want to step up the level of cooperation by using it as a platform to challenge accepted norms. Cooperation for cooperation's sake is not a good idea if it leads only to a plateau of progress or reinforces wrong practices. Essential to cooperative controversy is the willingness of everyone not only to influence, but also to be influenced. The result you are looking for is mutually advantageous solutions.

One of the most basic uses of this technique is to set aside a time before or after training sessions to discuss views, ideas, opinions and frustrations. Providing a formal basis for cooperative controversy avoids explosive and/or simmering disagreements during training. It also builds patterns of constructive engagement when time-outs are needed to resolve conflict. Encourage trainees to argue their beliefs during discussion and see that odd ideas are not simply dismissed. There should be no retribution for speaking out and therefore no fear of doing so.

Set up cooperative controversy more formally by assigning opposing views. This will get a dialog going and serves as practice for self-

initiated exchange. In addition, one person at a time can be assigned the role of criticizing the training project, helping to detect problems.

You can take the technique one step further. Ask trainees to prepare ahead of time by consulting various sources. They should seek out views, printed or otherwise, that disagree with each other and with you. When these are raised in group discussion, remind trainees that the aim is to use the material to create useful solutions.

Indicators
Cooperative controversy is useful for long term teamwork. It can also be used in situations where you think people are holding back or when they are in continuing dispute about training matters. It may also help trainees who feel offended when they are criticized.

Counterindicators
If training is very short, urgent or highly customized, cooperative controversy will not be very useful. Very large groups may need subdividing if this technique is to be effective.

Common problems
Good discipline is essential to ensure that cooperative controversy does not turn into a free-for-all. Human nature can lead discussion into personal issues and away from a basic exchange of ideas. In this way, cooperative controversy can spill out of its allotted time and result in the sacrifice of other effective training methods. Strong, diplomatic leadership is needed to keep this technique on track.

Related techniques
Behavior Modeling
Establish An Environment
Games And Simulations
Paired Post-Training
Sequence - Hard Or Easy
Stress - Emotional Training
Summarize For Class
Teams - General Methods
Teams - Cross Training

References

TIMING OF PRACTICE

Description

Timing of practice has three parts: Timing practice so as to get the most out of it; breaking practice into appropriately-sized sessions; and if needed to effectively perform the task, developing temporal independence, the ability to do the work regardless of time of day.

The gist is to break practice into absorbable chunks, space practice so it's best received, and vary practice time to generalize the skill.

How to do it

Two straightforward observations influence the timing of practice:

- People practice better when they are not fatigued.
- People absorb, integrate, and memorize unconsciously when not practicing.

Taken together, these two facts suggest that practicing in "absorbable", appropriately-timed sessions will be more effective than cramming. If fourteen hours are allotted for training a particular task, the scheduling seven days of two hour sessions, timed for when trainees are alert and ready, will result in better learning and retention than a single-day fourteen hour intensive.

The special case is with tasks where an important component is being able to perform effectively when fatigued. Firefighting is an example. Not only must firefighters perform under taxing conditions, but they must monitor their performance to determine when an unacceptable (potentially dangerous) level of fatigue has been reached. In this kind of case, timing of practice would be explicitly directed at inducing fatigue.

For some tasks—firefighting is an example, as are police work and medicine—effective practitioners must be able to perform well no matter what time of day or night they are called upon. "Temporal relocation"—the ability to perform no matter when called upon—like any skill is developed through practice. Timing practice to give the trainee opportunity to perform the task in a wide range of temporal settings improves the ability to generalize.

Time not thinking about something may actually be necessary to learn it. Recent work reports a roughly six-to-eight hour consolidation

period for new (physical) knowledge to transfer from short- to long-term memory. The study team found that overlaying other new and related skills on the target learning during this consolidation period resulted in diffusion or even elimination of memory transfer.

Students and trainees commited to mastering a skill know that working hard works, but Ericsson has found in his research on expertise that working beyond cconcentration is actually harmful. For self-directed practice, the drive to work hard has to be balanced with the need to take breaks—not so many breaks as to lose the thread, but then, being overly dogged is ineffective and may be harmful as well. What to do?

This is really a number of questions disguised as one. The right approach will depend on the nature of the task, the number of competing taks that must be performed or learned, variations in student interest in the task, and cyclical variations in the ability to concentrate.

A common thread through all of these, though, is self-management. If in conjunction with the timing of training, a specific goal is set for the learner to develop his or her study timing skills, then both can be learned concurrently. And it is easy to argue that the self-management skills will continue to grow in value as time goes on.

If practice is trainer-controlled, rather than self-directed, it is the trainer's responsibility to plan the practice sessions realistically with respect to the current capacities of his or her trainees. Finding the right level may be a process of trial-and-error, but close observation of trainees performance and attitudes can hasten this process.

It is less of special case than it might seem when training a skill that must become automatic (see Section XXX). In this case, though, once the basic skill is mastered the student's concentration still needs to be available, if only to be diverted so that practice of the automatic skill can continue while the learner's conscious attention is directed elsewhere.

A benefit of well-timed breaks, whether self-initiated or specified by the trainner, is that practice occurs at different times. In this way, learning is generalized to different temporal settings. A caution on

this—if it is desirable for the time or the place to be a cue to initiate the target behavior, then care in varying either is called for.

Finally, a rule of shaping can be used to help time breaks: Always stop at a high point.

Indicators
Whenever developing skill in a task requires hours of practice or study a day (or even hours a week), timing of practice sessions, both length and time of day, should be consciously considered. This is especially true if the trainees or students set their own training/study/practice schedules. To the extent that flexibility to adjust is present, timing of practice is something to plan with some thought.

Counterindicators
Sometimes it is impractical to space practice. Access to equipment, materials, or meeting space, the logistics of gathering people together, restrictions on the instructor's schedule—any of these can constrict the choices of timing.

With some skills and knowledge, prolonged practice is effective. For example, when becoming acquainted with new knowedge, immersion may be more effective than taking breaks of any length long enough to let the various new elements slip from the mind. This seems especially true when the material is new enough that significant mental energy must go into becoming oriented, building mental maps of how the various newly-encountered pieces all fit together. Note, however, that this is consistent with the notion of not exceeding the range of concentration. It may be the case that an implicit goal of practice is to expand that range.

Common problems
It is satisfying for trainees to feel like they have worked hard, and for motivated trainees it is easy to feel guilty about not working enough. However, sometimes working more now means being much less able to work later. Letting trainees push themselves beyond their ability to absorb and integrate the material they are trying to learn not only does no good, it may do harm. It is the trainers responsibility to monitor this and be certain it doesn't happen.

Trainees should be taught to monitor their own concentration. When

they work past their ability to concentrate, stopping is almost always better than developing a habit of performing the task with wanndering concentration or unconsciously learning erroneous performance. Returning to the work later will provide greater benefits than dogged but diffuse pursuit. For some tasks, even a five-minute break can be beneficial.

Related techniques for this training problem

Covert practice
Deliberate practice
Automaticity
Immediate practice
Practice alone (space practice when alone)
Stress - How to practice

References

Kylonnen and Alluisi
Holding

TRANSFER - IMMEDIATE APPLICATION

Description

Pentland (1989) found that having trainees apply their new skills immediately upon returning to their jobs resulted in a major improvement in long term retention. This means training should be timed so that the learned skills can be immediately applied, and that the training should be coordinated with the trainees' management so that assignments are made such that the trainees' new skills are actually used.

Immediate application aids generalization: The trainee will need to learn to do the task in the real situation and environment. No matter how realistic training is, it is still training.

"Generalization" is an important aspect of any training. Tasks are associated with environments, with where and when you do them. The more strongly the task is restricted to a single environment (a surgical theater, a laboratory), the stronger the association of task with environment. The positive benefit of this is that the environment comes to aid task performance, by providing a set of cues that trigger appropriate responses in the performer. A strong association with a single environment is negative, however, if the task needs to be performed in a variety of environments, whether that variation is physical, social, temporal, or all three. If that's the case—it usually is—task performance needs to be generalized.

Immediate practice on the job is always beneficial to generalization because at the minimum it helps generalize from the training to the real-world environments. It is usually beneficial because the job will probably have more environmental variation than the training. For the trainee to integrate his or her new skills into the total fabric of the work, that is, to generalize them, real-world application is necessary.

On the other hand, if you train people but they have no way to use the training when they return to their work, your former trainees will probably make a couple of simple inferences: "That training was a waste of time;" and, "the people who designed that training don't have a clue about what we really do." This may not be the desired

outcome of your training plan.

How to do it

Make certain trainees begin performing the task with adequate regularity immediately after they finish training.

Doing it right off the bat makes it into something they will subsequently expect to do. This in turn cements the importance of the new skill, and of its continuing to development. On the other hand, if on return to work chances for application of the skill just don't arise, people will come to believe that the new skills may be irrelevant, not important enough to devote any mental energy to remembering. The longer they go before they can apply their new skills, the greater the potential decay of training effect. This can even be exacerbated by a potential increase in any fear or sense of intimidation they may have (or may develop).

Indicators

The more complex the skill, or the more complex the task environment into which the skill is to be integrated, the more important immediate practice is. If there is a high proportion or procedural knowledge, this also increases the importance of immediate application.

Counterindicators

Immediate practice may not be possible. If you train firefighters in chemical spill containment procedures, it is probably not a good idea to derail a train so they can get real-world practice. (This is not a book about law, though. State regulations may vary!) If immediate practice is impossible, very difficult, or simply inappropriate, then periodic refresher training and/or practicing parts of the task may help.

Common problems

If for some reason, training can't be optimally timed, this should be explained to the trainees so that they have appropriate expectations. For instance, perhaps a kind of heavy equipment is being trained. It may be that the company isn't due to receive the equipment for six months, but now is the only time the trainers are available. If situations like this are unavoidable, then full disclosure to the trainees should be made.

When they go back to the job and begin applying their new knowledge, it's beneficial if they apply all of what they have been taught. Commonly, people remember only part of what they have been taught. Then when they practice, only that part gets cemented. If the person comes to believes they have learned the skill, or learned enough of the skill to get by, the material that was inadequately practiced will be forgotten unless the task environment absolutely demands it. (People are remarkably clever about getting by with whatever skill set they have.) Unobstrusive observation, or delayed traininng refreshers, can help here.

When they begin applying their new skills, they should have a grace period in which tolerance for error is higher than normal.

Related techniques
Limit Introduction
Learn By Doing Only
Learn By Mucking About
Post-Training and Transfer
Feedback—Action Vs Learning

References
Tannenbaum and Yukl
Pentland

VISUAL CUES AS PROMPTS

Description

If you are training someone to do something that you can show them how to do in detail, and the task requires choices to be made based on what they see, it can be a good idea to supplement the normal visual cues with strong visual cues (e.g., color cues) that are easier to notice and understand. This can be looked at as a form of prompting.

How to do it

Add visual cues that indicate different actions, e.g. red means turn the handle left, green means right. Make the cues part of the background, trying not to overshadow the actual cues that you are training the person to use, but accentuating those cues.

One thing to note is that if you put in artificial visual cues, the person may not learn to make use of the meaningful cues that are present, because the artificial ones are enough. So you have to ween them from those fairly quickly, and make the correct cues salient. Holding also suggests that you use the color cues for one problem at a time, and let them learn to do each right before moving on to the next, so that they do not become too dependent on the artificial cues.

Indicators

This approach can be used when training tasks based on visual perceptions and where the cues are not ambiguous. This doesn't mean they are easy to see, necessarily, but in the presence of a certain cue, it is possible to decide exactly what to do (so that associating a certain prompt with that cue is always appropriate).

If there is some other type of indicator, e.g., a sound, or a touch, that can be added to the same effect, that would also work. The original author, Holding, only discussed visual cueing. An extension to Holding's work could be to use auditory cues with auditory discrimination tasks, or touch cues with touch-based ones. It may also be possible to mix sensory cues, using for example an auditory cue for a visual discrimination task. Holding's suggestion is that you use the cue as a background for the actual cue that they are supposed to learn to use.

Counterindicators

Putting in visual cues along the way may be very difficult, if it interferes with the task process or interface. You wouldn't want to add a bunch of little lights to the console of a plane, for example, or try to add artificial cues to a basketball game - though both of these are activities where decisions are based on what you see.

Common problems

Don't allow trainees to become overdependent on the artificial cues.

Related techniques

Visual Cuing For Navigation
Avoid False Recognition
Feedback

References

Holding

VISUAL CUES FOR NAVIGATION

Description
For motor tasks such as the laboratory maze of tracking tasks, it is good to show the subject where to go, instead of letting them use trial and error. You do this by marking the correct path with a visual cue. This works better when you do not merely mark the correct path, but also mark as wrong the ones that the subject should not take.

How to do it
At each decision point (fork in the road) put an indicator telling the trainee whether it is a place to turn. Also mark places where they should never arrive so that they get back on the right track if they make a mistake.

Progressively remove the cues, let the trainees try it (using the remaining cues) and then put the cues back so that they can once again follow them, but this time with the natural cues also being noticed.

Indicators
When training someone in navigating or tracking. It only works when they are going to get to practice actually going through the target place, because they have to see the cues.

Counterindicators
If you can't give them visual cues then this technique might not be beneficial. For example, it may not help to say "don't turn at the big cow sign," even though it would help if you could put a red marker on the cow that indicates they should not turn there.

This technique takes some effort, especially in a real-world setting.

Common problems
If people come to rely on the cues you put in place, they will not pay as much attention to the cues intrinsic to the path. If you want them to learn how to navigate without the cues, then you have to make sure they notice the intrinsic cues.

Related techniques
Visual Cues As Prompts
Avoid False Recognition
Learn By Doing Only (Alternate)

References
Holding

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WHO WE ARE

Syukhtun Research, Inc., is a small artificial intelligence and simulation company located in Santa Barbara, California. "Syukhtun" (pronounced "syook' toon") is the Chumash word for the place they had lived for three to five thousand years prior to the arrival of the Spanish. It's a nice place.

Jim Kornell was the principal investigator. He has a B.S. in Computer Science from the University of California, Santa Barbara, and twenty years experience in software engineering, AI, simulation, and training. Nate Kornell (B.A., Psychology, Reed College) assisted in mapping out the space of training techniques, data analysis, and Java programming. Susan Fischer (Ph.D, Psychology, UC Santa Barbara) helped with the design of the teamwork survey and with its interpretation. Maria Gordon helped with writing and editing the content of this site. Max Kornell designed and (excluding the Java) built the site.

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